Spinal Column

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WHEREVER WE TURN—whether to the battlefields of war or to the civilian casualty fields of industry, the home, and the road—the human spine is today in constant jeopardy, suffering injury as never before

Wounded lying on the battlefield Airplanes smashing to the ground Parachuters bailing out unsuccessfully Jeeps and tanks overturning High speed submarine chasers racing over choppy seas Commandos landing in the dark The list is long with industrial speedups and blackouts and road accidents adding their quota to the staggering total of potential, if not actual spinal injuries facing the medical profession today

And so far as we have been able to ascertain, up to date there has been no quickly assimilated source book on spinal surgery to which the busy surgeon could turn for needed guidance It was to help fill this gap in the literature that *Surgery of the Spinal Column* was undertaken In its pages will be found not only our own technics but in many instances the technics of our colleagues which have found wide acceptance with others for the yardstick for inclusion throughout has been the judgment of those whose opinion we consider worthy of respect although not always concurred in by us

It was the Senior Author s privilege in the last world war to see the practice of bone graft surgery which he had sponsored so heartily since 1911 spring into prominence and achieve the envied role of saving thousands of both lives and limbs (He personally saw—or operated upon—thousands of such cases) In this current world war we expect to see both old and new applications of bone graft surgery—particularly as it applies to spinal surgery—play a similarly significant role

In the following pages appear chapters on all the various phases of spinal surgery as seem in our opinion pertinent to the reader s needs First the history of spinal surgery is given to show the truly amazing antiquity of this phase of surgery as well as its amazingly slow growth until the advent of the x rays and modern bone graft instrumentation caused it to outstrip within the past two or three decades, the previous progress of two or three centuries

Next comes a chapter on the armamentarium necessary for successful spinal surgery Chapters on the anatomy of the spine laminectomy

fractures and fracture dislocations of the spine tuberculosis of the spine static deformities congenital deformities and anomalies, low back pain and affections of the lower back, including a full discussion of the herniation of the nucleus pulposus and slipping of the intervertebral disc, osteomyelitis spondylitis, tumors, and miscellaneous affections of the spine follow in the order given Technics applicable to more than one phase of spinal surgery are discussed fully in connection with the operative condition where most frequently employed, and reference made to this section elsewhere Because of the wide contemporary interest in such subjects as low back pain tuberculosis and fractures of the spine, unusually generous chapters on these subjects have been considered advisable

It is hoped that the numerous illustrations will add the necessary graphic understanding to the text, and together the two will provide the seeking surgeon with all he requires to ameliorate the spinal suffering within his own practice

We wish to acknowledge our debt to the various sources listed in the bibliographies following each chapter and to the several publishers who so kindly have permitted the reproduction of drawings and other illustrations from their publications It is also a pleasure to pay tribute to the Senior Author s son Fred H Albee, Jr and to Miss Dorothy Abel for their invaluable aid in the preparation of this book

FRED H. ALBEE
EARL J POWERS
HAROLD C. MCDOWELL

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The History of Spinal

Spinal surgery as we know it today is a compound of ancient wisdom and modern practice Its basic origins and development antedate history and in all likelihood, are as old as man himself Out of the caves and burial grounds of prehistoric peoples have come skeletal remains showing many of the same types of osseus lesions as afflict man today, as for instance—osteomyelitis, hypertrophic and destructive arthritis periostitis osteitis, bone tumors and fractures Ruffer reports the finding of an Egyptian mummy showing lesions believed to be those of Pott s disease (tuberculosis) with a coexisting psoas abscess

Definite evidences of skeletal surgery—frequently in the form of finger amputations and trepination—have been connected with the neolithic period during which man first learned the use of metal, but it was not until the rise of the Greek civilization, and the advent of the great Alexandrian anatomists of the 3rd century B C. that medicine and surgery first became a science and spinal surgery *per se* is known to have existed During this period, deformities of the spine were made the subject of major study and in the *Corpus Hippocrates*, an amazing collection of books written by these first surgical masters sometime between the 4th and 1st centuries B C.—and credited to the physician for whom they are named—can be found many of the principles if not the methods now in orthopedic use

The Hippocratic school distinguished between deformities due to trauma and disease and the many varieties of curvature of the spine—even in persons of good health—caused by faulty habits and old age The Hippocratic text was the first to suggest the possibility of a relationship between spinal deformity and pulmonary disease, and the difficulty of its cure was recognized The role of the ligaments was known, and for this reason dislocation without coincident fracture was considered improbable The serious consequences of spinal deformity whatever its etiology

were also understood, and while correction was believed to be beyond the range of possibility efforts to obtain it were tireless

For post traumatic gibbus, these early surgeons advocated the fastening to the ground of a broad board with an oblong furrow in it, and the stretching of the patient thereon Repeated suspension—either by the armpits or by the legs in an inverted position—and prolonged recumbency on a hard mattress was also practiced

With the decline of Greece, and the rise of Rome, the latter in turn became the center of the scientific world Here in the 2nd century A D Galen made tremendous contributions in the fields of anatomy, embryology and neuroanatomy It was he who first suggested the treatment of spinal curvature in terms of active correction and he is credited also with having coined the words *kyphosis lordosis,* and *scoliosis* As a step toward the proper concept of vertebral tuberculosis he pointed out caries of the vertebrae as a cause of spinal deformity

Paul of Aegina (625-690 A D) made the next known contribution to spinal surgery His treatise, which became a medical textbook for centuries included the first description—if practiced—of a simple laminectomy Perceiving the possibility of giving relief in certain cases where for instance a fractured fragment of the posterior neural arch was believed to be impinging upon the spinal cord, he wrote having first given warning of the danger we must if possible, attempt to extract by an incision the compressing bone

Four centuries later as the Mohammedan-dominated Middle Ages drew to a close in the 11th century a new science of European medicine was born—free of all Eastern antidissection and antivivisection hindrances Students flocked to the newly established universities of Salerno and Bologna, there to learn anatomy as an essential basis for all surgical practice and anatomical research as the *sine qua non* of scientific surgical study

With the introduction of cannon shot at the Battle of Crecy in 1346 surgery again entered a new era But it was not until 1762 that Louis is credited with being the first to operate upon a fracture of the spine caused by a gunshot wound, and this was only a superficial operation on the neural arches Surgery upon the spine in which the cord was exposed proved universally fatal until the middle of the 19th century

The actual beginning of modern spinal surgery dates from 1564 when Ambroise Paré issued his famous treatise, the *Dix Livres de la Chirurgie*, in which he discussed the classic symptoms of cord compression and advocated the procedure suggested by Paul of Aegina. "Having made such a prognosticke you may make an incision so to take forth the splinters of the broken vertebrae (in cases wherein the neural arch was injured) which driven in presse the spinal marrow and the nerves thereof."

Paré also described congenital scoliosis, and treated it much in the Hippocratic way, save that he added steel corsets—the forerunner of the modern spinal brace and plaster jacket.

Contemporary to some degree with Paré was Girolamo Gabrizio d'Aquapendente (1537-1619) who invented an apparatus for the correction of torticollis and another for the gradual reduction of a gibbus. Contrary to the current theory of forcible correction of spinal deformities he advocated gentle manipulations with repeated adjustments of the spinal brace.

Also of this century was Dalechamps, a French surgeon, who two centuries before Percival Pott added a very important factor to the understanding of vertebral caries by discovering its relationship to paralysis of the lower extremities. In 1632 Marcus Aurelius Severinus restated Dalechamps' observations that caries vertebrae follow the formation of tubercles.

The understanding of vertebral caries was further advanced by a case described by William Fabrig of Hilden in a report published in 1641. Fabrig also published the first pictorial description of scoliosis from studies he made of anatomic sections of a child's spine, thus adding greatly to the knowledge of the complexity and progress of such spinal deformity.

A little later in London, Richard Wiseman, the foremost British surgeon of his period (1648-1686) made an outstanding contribution to surgical history by clarifying the numerous manifestations of surgical tuberculosis and demonstrating their underlying unity.

Meanwhile in Holland spinal surgery was also receiving considerable attention during this century. In 1685 Isacius Minnius performed the first known operation of tenotomy for wry neck. Henrick von Deventer, most important of the contemporary Dutch surgeons, who had become

interested in bone deformities because of the many abnormal pelves he encountered in his practice of obstetrics contributed greatly to the understanding of such conditions by writing up his outstanding cases For the correction of scoliosis he advocated the use of suspension apparatus designed to take full advantage of the force of gravity

Fresh impetus to the study of curvature of the spine was given by Nicholas André Professor of Medicine at the University of Paris who in 1741 coined the word *orthopaedia* from the Greek roots *orthos* (straight) and *pais* (child) and wrote extensively on the subject. He devised a system of treatment devoted largely to postural training and based on his theory that in the absence of trauma or destructive disease lack of symmetrical development of the human skeleton was due to postural improprieties during the formative years resulting in improper muscle balance.

Although since the time of Hippocrates the tuberculous nature of gibbus spine had been suspected and recognized vertebral tuberculosis in 1779 became Pott s disease as a result of Percival Pott s discussion of the paralysis of the distal spine segments which may follow a gibbus, or any case of vertebral disease not properly treated

Also of this period was John Hunter another Englishman who performed the first known bone graft by transplanting the spurs of a chicken to its head and is thus credited with having begun the science of modern experimental surgery

Almost a century later in 1853 partial luxation of the lumbar vertebrae received its name spondylolisthesis at the suggestion of Kilian, after Rokitansky had described it as a pathological entity in 1839 and mention of it had been made by Herbineux in France during the previous century In 1882 Neugebauer restudied it and published many papers on it and since then—and up to the present time—it has been the subject of innumerable investigations

In comparatively recent years much attention has been paid to the pathological variations of the nucleus pulposus of the intervertebral discs and to the discs themselves Roux, in France, pointed out that when pressure is applied to the intervertebral disc, the nucleus pulposus reacts in a manner different from that of the rest of the cartilage In 1928 Schmorl of Dresden stirred up a controversy by publishing the results of

his study of the effects of the herniation of the nucleus into the spongiosa of the adjacent vertebral bodies if, under pressure, the fibrocartilagenous covering bursts—a condition, which, according to his findings occurs often in apparently healthy spines Because of its frequent presence without symptoms Schmörl wrote that its importance lies in the necessity for distinguishing it from less innocuous lesions Earlier in 1922, Calve had warned against confusing calcification of the nucleus pulposus with the lesion of Pott s disease

In 1911 Goldthwait in Boston and Middleton and Teacher in Glasgow, each independently reported a series of cases which had been diagnosed as spinal cord tumors until operative exposure disclosed their true nature, and the fact that the intervertebral discs had ruptured into the spinal canal causing pressure upon the cord

During the past decade intervertebral discs and nuclei pulposi have been given—and are being given—a great deal of attention and a number of operations have been performed upon them for the cure of low back pain

Sir Astley Cooper (1768-1841) was the first to advocate operation on fractures of the spine Rogers in 1835 in speaking of a case of fractured spine with depression of a spinous process and the operation for its removal, says Although all the cases of depression of the spinou processes in which an operation has been performed have proved fatal I think that in a case of simple depression of spinous processes without any injury of the spinal cord we have a reasonable prospect of success in an operation In all events it is the only chance for the patient, and under such circumstances I recommend it

This attitude however was probably in advance of the times for we find that as late as 1867 John Ashhurst Jr gathered statistics to show why operations of this type should not be done and even in 1893 Cheever and Manley published a paper advising against operation in fractures of the spine

Modern methods of fracture therapy began with Hugh Owen Thomas of Liverpool (1843-1891) who made early designs of most of the fracture splints now in use, including shoulder abduction spinal braces and head elevation apparatus and whose work represents according to Bick, an emphatic reiteration of those fundamental principles upon which the

proper care of fractures depends, and from which, from time to time, brilliant surgery veers

As a forerunner of the convex frame used in the treatment of spinal deformities and fractures, Robert Chesshes, an English country practitioner devised a double inclined plane for the treatment of spinal disease and injuries

In 1852, Mathijsen, a Flemish army surgeon introduced the use of plaster of paris bandages as a substitute for braces in the immobilization or support of skeletal injuries, and Lewis Sayre of New York first adopted this method as a support for the spinal column in cases of scoliosis and vertebral tuberculosis

Since the time of Paré, numerous operations had been performed on spinal curvatures for various reasons—mostly however, cosmetic The first real operative attempt to stay the progress of a spinal curvature was made in 1891 by Hadra of Galveston, Texas He attempted to fix the spine by twisting silver wire about the spinous processes of the sixth and seventh cervical vertebrae in a case of fracture dislocation. Lange, of Munich, substituted the first silk ligatures for the wire, and then in 1910 advised the insertion of a celluloid plate beside the spinous processes in order to immobilize a large area of the spinal column

The discovery almost a century ago that the anterior and posterior roots of the spinal nerves are motor and sensory in function was made at about the same time by Sir Charles Bell and Magendie This constituted an advance of far reaching importance in the surgery of the spine and spinal cord

It was not until 1911 however that any adequate method of fixation of the spine was discovered and in that year not one method but two were discovered almost simultaneously by Russell A. Hibbs of New York, and the senior author These two methods of fixation which have almost completely revolutionized the treatment of spinal surgery although somewhat different in their performance tend to produce the same thing—fusion of the spine

The Hibbs fusion is an osteoplastic operation for immobilizing the spinal column In this operation the periosteum is stripped from the posterior arches the spinous processes are split and made to overlap the interspinous spaces fragments of bone are raised from the laminae and

placed in the interlaminar spaces In addition each intervertebral articulation is individually curetted and denuded of cartilage

The Albee fusion is an implantation of a tibial bone graft along the channel of the split spinous processes The incision is carried through the skin and subcutaneous tissue exposing the tips of the spinous processes The interspinous and supraspinous ligaments are then split With a wide osteotome the spinous processes are divided into halves the half nearest the operator being broken laterally so as to present throughout a channel for the graft which is taken from the crest of the tibia—care being taken not to fracture the other half of the spinous processes The leg which has been prepared for the taking of the graft is flexed upon the thigh and the incision is then made over the tibial crest until the anterior surface of the bone is exposed The length and shape of the desired graft is then marked off on the exposed tibia By means of the twin saw the graft is removed with the periosteum intact This is placed in the channel prepared for it along the split spinous processes, and is secured there by interrupted kangaroo tendon and chromic sutures

This operation is thought by the authors to provide the best possible type of fusion—first, because of the speed of its performance secondly because it brings to the sluggish callus-forming bone of the spinous processes bone which has a high osteogenetic ability and third because in the author s hands it has resulted in a remarkably high percentage of successful fusions In contrast, the Hibbs operation, dealing with small fragments of bone of low osteogenetic potentiality is a most time-consuming and hence shocking procedure—so much so that men like Gallie Robertson and others have given it up completely

At the present time the authors use spinal fusion in Pott s disease, in scoliosis—both idiopathic and paralytic, in certain cases of fractures of the vertebral body in congenital deformities, the herniation of the nucleus pulposus and slipping of the intervertebral discs in spinal arthritis and in many other diseases of the spine itself

Thus we see that spinal surgery has made immense strides and how new instruments—especially those driven by electric power together with improved methods of procedure have simplified and extended surgery of the spine and spinal cord.

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Thus we see that spinal surgery has made immense strides and how new instruments—especially those driven by electric power together with improved methods of procedure have simplified and extended surgery of the spine and spinal cord

We must remember however that surgery is no more static than life itself and as various modifications in operative technic are evolved, and changes in suture material and surgical instruments effected, what today may be the subject of justifiable criticism may tomorrow be corrected as vertebral surgery now in its comparative infancy learns to walk.

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CHAPTER II

Armamentarium

Spinal surgery is so highly specialized in its nature, and requires such specific instruments for its successful execution that few hospital surgical departments are adequately equipped to handle such cases—despite the increased attention now being given to bone surgery

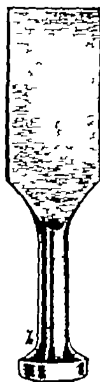


Fig. 1 Albee osteotome for splitting spinous processes. (*By courtesy of Kny-Scheerer Company*)

A complete armamentarium for the surgeon undertaking spinal surgery should contain the following

1 A fracture table—either the Albee-Comper Fracture Table or one similar in type

2 An electro-operative bone outfit, with a non flexible shaft preferably—as flexibility diminishes the versatile application very materially

3 Suitable retractors—sharp-pointed and rake of varying sizes and depth of tooth

4 Bone clamps

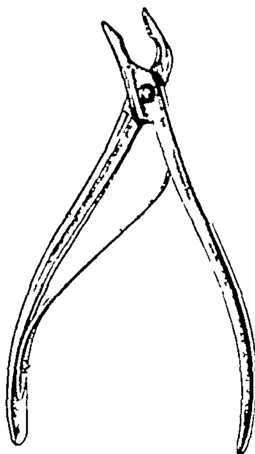


Fig. 2 Rongeur for widening the spinal opening. *(Albee's Orthopaedic and Reconstruction Surgery W B Saunders Co)*

5 Bone elevators (*e g , Lane's*)

6 Kangeroo tendon of various sizes and materials for external and internal fixation

7 Sharp thin osteotomes of various widths The author never under any circumstances uses a blunt-edged chisel There is so little flexibility in bone that it crushes or breaks very readily under the chisel and for that reason, a thin edged osteotome is preferable

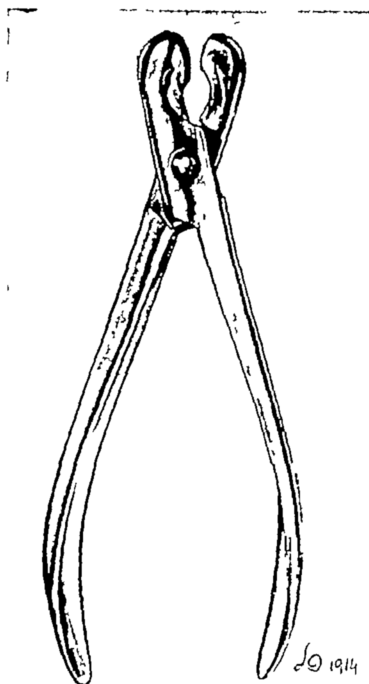


Fig. 3. Large rongeur forceps for the removal of the spinous processes. ×2/3. (Elsberg.)
(From Albee Orthopaedic and Reconstruction Surgery W B Saunders Co)

8 A laminatome

9 Rongeurs of various types and sizes—x ¾ (Elsberg) for widening the spinal opening, and the large rongeur forceps, x ⅔ (Elsberg) for the removal of the spinous processes

10 Lion jaw forceps

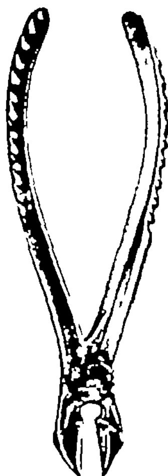


Fig. 4 Horsley spine forceps X2/3 (Elsberg.)

11 A heavy mallet This should be large and of solid metal although one of lignum vitae is very good

12 Suitable materials for external fixation dressings The importance of this should be emphasized It is believed furthermore that every surgeon having anything to do with bone surgery should thoroughly master the plaster of paris technic.

13 The Balkan Frame

14 Skull traction apparatus

The Electro Operative Bone Mill—and Technic of Its Use

In modeling a bone graft into dowels wedges and inlays, and in making use of the different well known mechanical devices such as tongue and groove joints, dovetail joints, mortices etc. in spinal surgery, the motor outfit is indispensable In many instances, an accurate cabinet maker s fit may mean success where the ordinary crude coaptation would spell failure



Fig. 5 Albee bone drift, prototype of the carpenter s nail set. This is an instrument which I use very frequently in seating grafts, whether they be of the inlay type peg type etc. *It is used similarly to the carpenter s nail set. (From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Co., New York.)*

It is only when the most precise cabinet maker s type of fit has been secured, that the full value of what is called *Roux's law of frictional stimulation to osteogenesis* is obtained—a most important factor in stimulating callus formation and securing union As has been said in

Electrically Driven Circular Saws and Drills

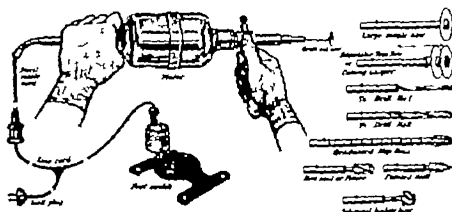


Fig. 6.

Bone Graft Surgery * "The entire process of union and the survival of the graft depend on the establishment of vascular connections be

* Bone Graft Surgery by F H Albee W B. Saunders Company Philadelphia and New York, 1915

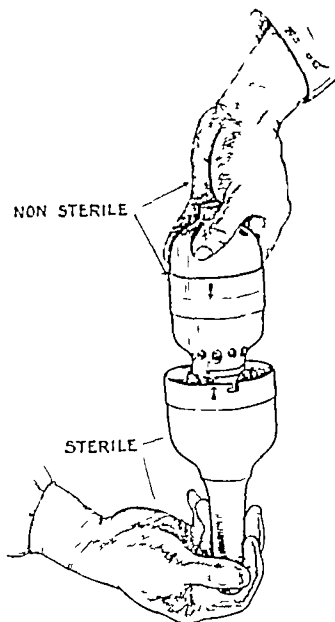


Fig. 7 In assembling the motor the surgeon holds the recipient shell (its orifice uppermost, like a goblet) both the shell and the surgeon's hand being sterile. An assistant (whose hands are non-sterile) inserts the shaft of the motor (which has not been sterilized) into the recipient shell and turns it to the right until it can be turned no further and the arrow on the shell comes in line with the arrow on the motor

tween the graft and the host fragments the rapidity of establishment and the degree and permanence of vascularization vary directly with closeness of coaptation and rigidity of immobilization these depend on accuracy of fit The necessity for the greatest precision in the mechanical procedures needs no further argument ideal conditions can be produced in no other way than by the use of automatic power driven tools which can be adjusted to cut with mathematical exactness both the graft bed and the graft which is to fill it with glass stopper precision.

The ideal electromotor outfit should measure up to the following requirements

1 It should permit of the thorough and rapid sterilization of every part which comes in contact with the surgeon or the field of operation including the electric cable for transmitting power

2. It should permit of ready application to all types of osteoplasty whether situated superficially or in a deep wound whether involving the procuring of a graft, the preparation of its bed, the drilling of holes the removal of bone for the correction of deformity or the curing of disease or to permit the proper approximation and alignment of bone fragments in cases of fracture.

3 It should permit accurate control and guidance of the motor cutting tool in all wounds and at all angles The flexible shaft formerly used in dental outfits, but given up some years ago is not suitable for transmitting the power of the cutting tool, because it causes the cutting tool to vibrate or chatter and does not allow it to be directed in every conceivable direction A flexible shaft strong enough to drive a twin saw satisfactorily through the adult tibial cortex no longer remains flexible enough for versatile surgical application

4 It should permit easy and convenient control of the electric current and speed of the cutting tool

5 It should be light in weight small in bulk, and permit of easy transportation

6 The motor should be of a universal type, and adapted to all kinds of motor electric currents

7 The motor instruments—*saws of different types drills lateral cutting and end mills* dowel shapers etc. should be held in place in the motor by an automatic catch facilitating their speedy interchange

8 The motor cutting tools should be constructed like those long used by the artisan for working hard materials They should be of a variety sufficient to meet every requirement of bone carpentry or machine work and should include all kinds of automatic tools The twin saw for inlay work should be so constructed that the gloved hand of the surgeon at the operating table can readily adjust it to the fraction of a millimeter

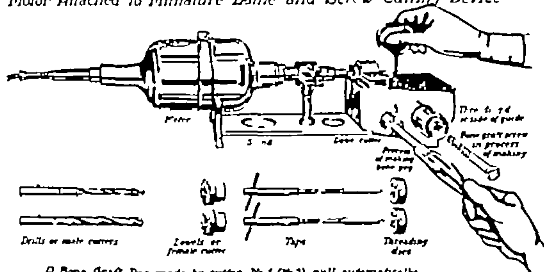


Fig. 8. Motor attached to miniature lathe and screw-cutting device (*By courtesy of Kay-Scheerer Company*)

Dowel-shapers should have interchangeable cutters of sizes varying sufficiently to meet all requirements Various motor driven dies should allow threads to be put on pegs of any size, thus transforming them into screws Corresponding size drills and taps make the threaded holes for the reception of the bone graft screws

9 The motor should furnish enough power to drive a twin saw or large drill through the thickest cortex of human bone rapidly and without any tendency to stall The motor tool is best attached directly to the motor shaft To enable the surgeon to hold the motor in his hand while the tool is cutting the motor should be covered by an adjustable sterilizable shell its weight—four pounds—has been found to be an advantage, rather than a drawback in its application

The Albee Comper Fracture Table

Due to the stress of recent times with increasing motor accidents, mishaps in sports industrial injuries and various infections a wider field of corrective spinal surgery has developed, with more specialized demands in the matter of surgical equipment The greater part of this type of surgery being of a major nature, cannot be performed on the surgical operating table because of the lack of tractional facilities and many other essential features and fracture tables being designed primarily for the reduction of fractures are completely lacking in many of the essentials for operative procedure This is particularly true in spine work, where the demands are manifold in their variety and most exacting in their precision requirements

The Albee Comper Fracture Table was created to meet the need for a universal surgical table combining in one compact, self-contained unit the elements necessary for promoting the success of all kinds of general surgery as well as traumatic and orthopedic work. This table while conforming to the long established and well tried principles nevertheless departs entirely from the conventional standards of fracture table design The essential features of the operating table have been adopted and to these have been added simple and efficient mechanical innovations including a crank-operated crane and unlimited facilities for *accurate x ray examination before, during and after the operation*

The Albee-Comper Fracture Table is mounted on large substantial wheels making it easily movable from Plaster Room to Surgery Floor lock and Trendelenberg angle for spinal anesthesia or treatment of shock during the operation are combined on the same control at the end of the pedestal The one piece overhead frame is instantly removable and fully adjustable. *It has a lateral tilt controlled by a crank and a* variable height range controlled by a hydraulic pump—precisely as the modern general surgical operating table Removal of the table panel at the foot end enables the assistant surgeon to stand between the patient s legs in close relation to the operating surgeon The construction of the table permits unparalleled approach for anteroposterior radiographic or fluoroscopic examination of the spinal column in hyperextension

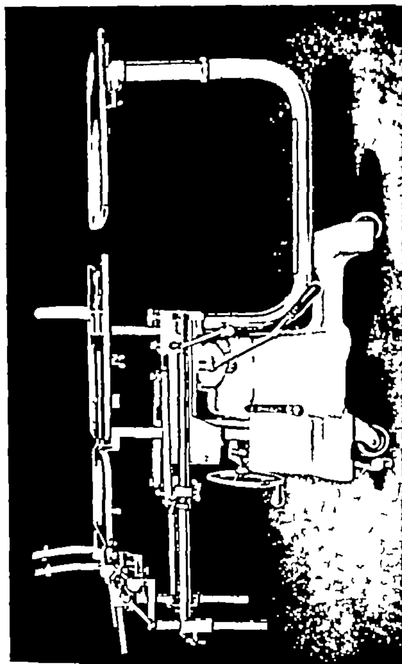


Fig. 9 The Albee-Comper Fracture Table is a mobile and unusually compact unit for use in all types of orthopaedic and spinal surgery (*Bone Graft Surgery in Disease Injury and Deformity* Fred H Albee D Appleton-Century Co., New York 1941)

The controlling mechanism is housed in a pedestal base as an entirely independent unit, resting on casters which may be locked at will To this pedestal is attached another completely independent unit—a superstructure comprising the table top, traction apparatus perineal post and sacral

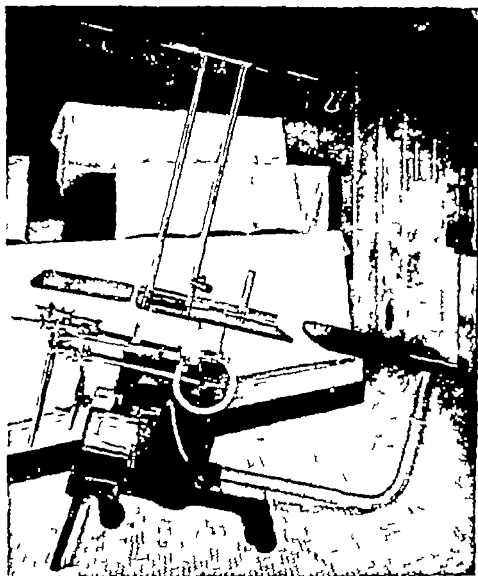


Fig. 10. Table in Trendelenburg angle for spinal anesthesia or treatment of shock during the operation. *(By courtesy of Comper Manufacturing Company)*

rest Consequently, when lateral tilt for instance is applied, no distortion or diminution of traction in relation to the patient occurs and the perineal post and a conventional body support prevents any tendency of the patient to slide out of position on the table

In this superstructure are embodied the following mechanical aids to the management of every desired orthopedic posture of both extremities as well as the spinal column, whether for open surgery or closed reduction The telescopic traction rods universally adjustable for both upper and lower extremities are of new design They embrace the author s lateral adjustment of the upper end of these traction rods in accordance with the size of the pelvis or intra hip joint distance of each individual patient to insure their being hinged immediately under the hip joints The amount of traction thus remains constant throughout the excursion of the traction rods regardless of the degree of abduction or adduction applied

In the hyperextension treatment of fractures of the spine (Davis etc. positions), a winch with canvas sling is placed in sockets on the table top and when the patient s legs are attached to the overhead frame the table sections may be removed and hyperextension obtained by slackening canvas, through control of the winch Precision control of desired posture and crane control in a vertical direction at the foot of the canvas enable the sling to hug the symphysis closely for accurate application of a plaster jacket Ample space is provided under the abdominal region for management of obese patients in hyperextension and for x ray or fluoroscopic examination in any plane without disturbing the posture or immobilization of the patient

Other fracture tables which have their advocates are the Hawley Scanlon and Bell tables The latter is reputed to be particularly adaptable to the application of hyperextension casts by either the sling or hammock method

Materials

PLASTER OF PARIS

The plaster of paris used in surgical work should be of the same superior rapid setting type as that used by dentists (The authors prefer that manufactured by the S S White Dental Company) It should be packed in airtight tin pails to prevent hydration from the air To further prevent hydration the pails—in the intervals between use—should be stored in dry locations and when in use the hand introduced into the pail should be perfectly dry

Occasionally because of some accident during the process of manufacture or from a break in the hermetic seal a particular specimen of plaster will not harden properly Such a specimen should be returned at once to the manufacturer, or put through a slow baking process to effect dehydration

When such hermetically sealed dental plaster is used, the addition of salt to the immersion water is not only superfluous but undesirable, because it causes the plaster to become brittle

Crinolin Although a variety of fabrics—gauze, dextrin gauze, flannel etc.—have been used for impregnation with plaster of paris, it has been found that crinolin (gauze sized with some stiffening substance) is by far the most satisfactory material for this purpose. An unsized bandage is worthless in this connection as is a bandage with too much sizing which prevents the plaster from setting Many of our largest clinics have found by experience that the hospital crinolin labelled H' and manufactured by the H B Claflin Corporation, is the most satisfactory *It comes in 12 yard bolts and its mesh should number 28 to 32* threads to the square inch

Preparation and Storing of Plaster of Paris Bandages The bolt of crinolin should be divided into two equal sections—each six yards long The selvages should be torn off and then each portion torn into roller bandages three to eight inches wide, as required. After these strips are rolled loosely the ravellings on the edges can be removed by rubbing the point of a pair of scissors over the ends and pulling away the loose threads thus dislodged Crinolin should never be cut with a knife or scissors unless cut obliquely after having been rolled because of the difficulty of following threads (It is impossible to remove short ravellings from an unevenly cut edge)

Impregnation of Crinolin Bandage with Plaster This is best done by placing a pile of plaster upon a smooth board—such as a bread board—and drawing the crinolin bandage through it rubbing the plaster into the meshes with the hand at the same time By holding the bandage to the left of the pile and unrolling it slowly this can be managed without too great difficulty The meshes should be rubbed just full—and no more No additional plaster should be sprinkled on after

wards and care should be taken that the bandages are not wound too tightly for storing

Storing The completed plaster of paris bandage is wrapped in a single layer of moisture proof paraffin paper and secured with an elastic band—or for lack of these materials in two or three layers of newspaper or wrapping paper and packed in tin pails with accurately fitting covers Such pails should be kept in the driest place available Plaster of paris whether loose or in bandages should never be stored in a basement If for any reason the airtight seal of the pail becomes broken and the plaster fails to harden well and quickly it can be restored by placing the tin container with the cover off in a very slow oven for a period of several hours after which the cover is replaced and the container set away in a dry place

Requirements of a Plaster of Paris Bandage The crinolin should be of such quality that the bandage when applied can be made to conform smoothly to the irregularities of the part to which it is being applied

The bandage should be so wound and so impregnated with plaster that when properly immersed in lukewarm water—on end—it will immediately become saturated and, during the process of application will not telescope If too tightly wound or too full of plaster it will have dry spots from the uneven penetration of the water If too loosely wound the center will push out during application—in other words, it will telescope. During its immersion in the lukewarm water the upper edge of the roll should never be squeezed as this will prevent the escape of air and penetration of the water from beneath As has been said the strongest and most efficient bandage is one that contains just enough plaster to fill the meshes of the crinolin—and no more

The plaster should harden *en masse* with sufficient rapidity so that when the surgeon has completed the final layers the bandage will be of the right consistency to give good splint support and yet be malleable enough to facilitate molding at the same time staying put

Padding Cotton sheet wadding stockinette and flannel have proved acceptacle for padding The authors however prefer to use sheet wadding purchased in large rolls and torn into strips varying from 4 to 12 inches in width and rolled into bandages One of the advantages of cotton wadding is that in removing the cast it yields to Stille s cutter in

a way that other materials do not. Emphasis should be put upon the importance of the even application of this wadding, due regard being paid to the protection of all superficially placed bony prominences, at the same time that even distribution is being preserved elsewhere The authors prefer to hold the wound dressing (postoperatively or otherwise) by means of the sheet wadding bandage, rather than by applying a gauze bandage directly over the sheet wadding bandage, as practiced by some surgeons because general swelling after any operation may cause the edge of the gauze bandage to become taut, and to act as a local constricting band causing further swelling at this point

Saturation of the Plaster of Paris Bandage Tepid water is generally used always in a container—preferably a pail—of sufficient depth so that the bandage standing on end will be entirely submerged. The higher the temperature of the water—within certain limits—the more quickly *the plaster hardens* The wrapper *if it is permeable by water, may be* left on or removed, as preferred The authors prefer its removal The bandage placed on end in the water is allowed to remain standing until air bubbles have ceased to rise indicating it is ready for use. Time is no guide to the completion of saturation, absence of air bubbles is the only criterion

Attempts to hold or squeeze the bandage while it is submerged with the idea of making it absorb water more rapidly cause agglutination of the ends of the bandage, and prevent escape of air and the water from penetrating to the center

After the bandage has been removed from the water it should be held by each end—the object being to prevent so far as possible the escape of fluid plaster It should then be very gently wrung out by a half turn of the bandage, so that when handed to the surgeon, it is in the shape of a flattened roll with about six inches unrolled. The saturated bandage should never be squeezed in the center or vigorously wrung, because thereby too much plaster is lost, and frequently the bandage is telescoped

Application of Plaster of Paris Bandage It is difficult to give clear and comprehensive directions for the application of an ideal plaster of paris bandage Dexterity can only be acquired by actual experience

The best method is to allow from six to eight inches of the bandage to be unrolled in advance of its actual application Great care should be taken to have the bandage smooth, without wrinkles and with its first layer so placed that slight, even compression is exerted throughout the extent of the splint The plaster should be constantly rubbed in during the application

The area is first entirely and evenly bandaged with two or three thicknesses By giving a larger area for drying this insures a more uniform



Fig. 11 Plaster jacket with jury mast, just applied. Note tilting back of head. The stockinet hanging down will be turned up over the jacket and sewed to itself at the top (Taylor)

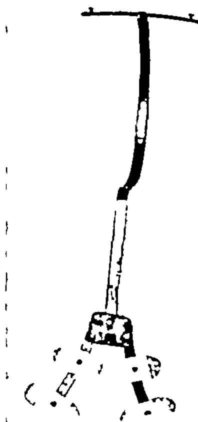


Fig 12 Jury mast. (Taylor)

(Albee's Orthopaedic and Reconstruction Surgery W B Saunders Co)

bandage and promotes rapid hardening It is impossible to state exactly how many layers should be applied in the average case—the quality of the plaster the rapidity of drying the condition of the patient, and the mechanical stress are the principal determinants of this

In cases of prolonged application the water should be changed at frequent intervals, since it thickens with plaster to an emulsion which fails to penetrate the bandage readily

Rubbing in dry plaster or plaster cream on the exterior of the dressing hastens hardening and gives a smoother surface When the plaster cast is to remain in position for a long time varnishing the cast is an excellent way to keep it clean and free from contamination and saturation by discharges

Plaster dressings well applied and of good material will last many weeks or months in fact the authors have removed plaster of paris jackets which have been in place for five years.

Jury Masts In cases of cervical Pott s disease, or other lesions of the cervical spine where fixation support is required a jury mast or chin-cup may be incorporated in the last layers of the plaster jacket No other special means of retaining the apparatus in the jacket is necessary

Turnbuckle Casts In cases of scoliosis a cast is sometimes applied with a turnbuckle incorporated in it so that by gradually opening the plaster on the side of the turnbuckle at a semi-circumferential cut in the plaster between the turnbuckle anchorages the condition can be gradually corrected by daily adjustments before the insertion of a bone graft A few weeks in bed is usually necessary in order to gain maximum correction

Technic of Hibbs Risser Ferguson Turnbuckle Jacket Cast A plaster jacket with a head piece is applied under moderate traction A hip spica which distributes the pressure necessary to fix the pelvis is attached except in very high dorsal curves Hinges made of two six inch pieces of 1 2 inch width strap iron riveted together are incorporated front and back over the crest of the curve, and two turnbuckle lugs are placed on the side of the concavity of the curve

After three or five days of drying the jacket is cut through between the lugs front and back to the point of motion of the hinges On the opposite side of the jacket at the level of the hinges, a window is made

which allows a space into which bending can take place As gradual bending by means of the turnbuckle continues compression of the body is substituted for lateral pressure Care must be taken during bending of the jacket to discover and relieve all new pressure points and the plaster edges should be bevelled



A *B*

Fig. 13. *A.* Hibbs-Risser Ferguson turnbuckle jacket cast. *B.* Correction of a mid-dorsal curve completed. Casts, with the exception of those for high cervicodorsal curves, usually extend to the knee on the side of the turnbuckle

In two or three weeks when the jacket is bent over about 90 degrees maximum correction is obtained This amount of correction is accurately determined by x ray examination The jacket is then reinforced by means of basswood plaster-covered struts and the turnbuckle and posterior hinge are removed An inner layer of plaster is applied to the body as a vest where the jacket has been spread which gives added immobilization A posterior window is then made exposing the operative area (Risser)

Removal of Plaster of Paris This is best done with a Stille cutter If this is not accessible, a saw or a heavy jackknife will serve the purpose. Hot water or vinegar may be used to soften the plaster after the surface to be cut has been scarified with a knife. After cutting the gutter, the plaster is spread with a special clamp

In removing a cast which has been applied for postoperative fixation, the field of operation should be carefully avoided

Plaster Corset If it is desired to make a removable plaster corset the dressing is cut from the symphysis up the midline of the abdomen and thorax to the sternal notch, then sprung off the trunk, and hooks and eyes and the covering of the corset applied so that it can be laced together like an ordinary corset

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Anatomy of the Spine

The Spine as a Whole

The spine or vertebral column consists of 26 superimposed bones or vertebrae, classified according to their regions as 7 cervical, 12 thoracic 5 lumbar, the sacrum and the coccyx. In the male, the length of the average spine is approximately 71 centimeters in the female, approximately 61 centimeters The cervical region in the male measures about 12 5 centimeters the thoracic, about 28 centimeters, the lumbar about 18 centimeters and the sacrum and coccyx about 12 5 centimeters together

The spine is the central pillar of the body and functions as two segments—the superior, long flexible portion supports the head and carries the thorax and abdomen while the inferior short, rigid pelvic portion carries the lower extremities The spinal column is enveloped and bound together by a series of well distributed and strongly resistant ligaments and the vertebrae are balanced one upon the other by a strong active musculature

Viewed in profile, the normal adult spine has four anatomical curves—two with their convexities forward in the cervical and lumbar regions and two with their convexities backward in the thoracic and sacral regions The upper three curves merge imperceptibly into one another but the lumbosacral junction presents a marked angle prominent on the anterior surface of the column at the sacral promontory Viewed from behind the vertebral column is vertical The normal curves vary however according to age In the newborn, the vertebral column shows two primary curves, both concave forward—the upper extending from the head of the pelvis the lower affecting the sacral region. When the child begins to sit erect, secondary curves appear the first of which is a forward convexity in the cervical region and later as the child begins to

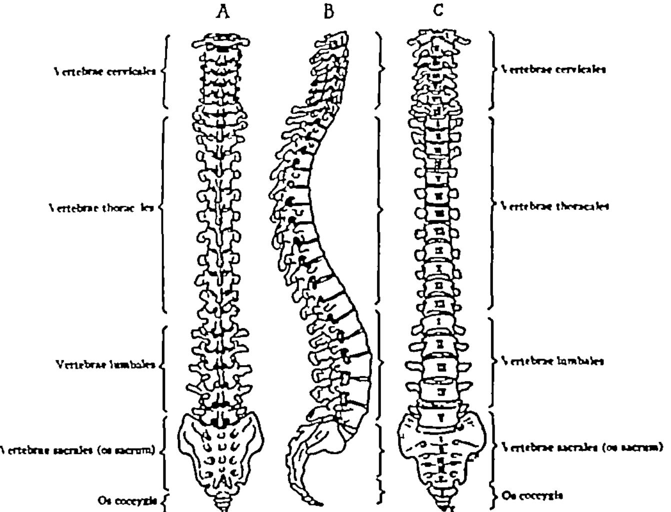


Fig. 14 Posterior lateral and anterior views of the spinal column. (*Callender's Surgical Anatomy* W B Saunders Co)

stand and walk a forward convexity appears in the lumbar region. It is due to the development of these secondary curves that the spinal column is able to transmit the weight of the trunk to the pelvis in such a way that little or no muscle effort is needed to maintain the erect posture. In old age the spine tends to assume one great curvature with an anterior concavity The lumbar curvature is greater in the female than in the male, and therefore makes a more marked anterior prominence at its junction with the sacrum.

Movements of the Spine Although the increments of motion between contiguous vertebrae are small, in the aggregate they are quite extensive and on the whole, the normal spine is capable of a wonderful degree of flexibility It is capable of rotation of lateral, backward and forward bending, and of circumduction These movements are to a great extent made possible by the compressibility of the intervertebral fibrocartilages The widest range of motion is in the segment where the discs are best developed It may be said here, however that it is due to the articular processes that the spine possesses its stability and capability of sustaining weight for without these braces, the column would be too yielding to give proper support

The curves and planes of the articular facets are also important factors in determining the character and extent of the movement between the vertebrae Thus in the cervical region, there is a wide range of all movement In this region the articular surfaces are oblique and approximately plane, allowing for a forward and backward flexion of about 90 degrees Lateral flexion although not favored by the obliquity of the articular processes, is possible through a considerable extent to about 30 degrees by the combination with torsion or rotation where one of the upper processes glides downward and backward while the other glides upward and forward on the corresponding surface of the subjacent vertebra.

In the thoracic region the articular processes are practically vertical and therefore ventral and dorsal flexion are opposed These movements are further restricted by the attachment of the ribs sternum and the imbrication of the spinous processes This, however, adds to thoracic stability and preserves respiratory function.

Lateral flexion on the contrary is much more free although it is curtailed to some extent by the attachment of the thorax There is a fair

amount of rotation permitted in this region and particularly so in the upper part of the thorax where a combination of lateral flexion and rotation or torsion may take place

In the lumbar segment, the unfavorable factors presented by the vertical position and anteroposterior concavity of the articular processes do not prevent a quite extensive anterior posterior and lateral flexion This is due to the looseness of the capsules of the articulation and the thickness of the intervertebral discs, permitting a gliding of the joint surfaces upon each other, together with the lumbosacral articulation Forward flexion reaches its maximum in the lumbar spine while rotation on the other hand is precluded, although a combination of the various forms of flexion may give rise to circumduction In the sacroiliac synchondrosis, there is only a very slight mobility This is characteristic of such joints which later in life become synarthroses

In general it may be said that the greatest mobility or movement of the spine occurs where one type of vertebra changes to another, and in those parts of the spine having the convexity directed forward at the place where the intervertebral discs are thickest Pathological exaggerations of the anteroposterior curve and deviations from the normal vertical plane are

1 Scoliosis—lateral deviation
2. Kyphosis—exaggerated posterior convexity
3 Lordosis—exaggerated anterior convexity

In general it may be said that the basic underlying factors in these deviations range from faulty attitudes or postures to traumatic and diseased processes.

General Characteristics of the Vertebrae

The vertebrae making up the flexible and flexuous vertebral column which extends from the base of the skull to the inferior extremity of the trunk are classified as stated previously according to their topographical region as the cervical the thoracic, the lumbar and the sacrococcygeal The first three groups comprise the superior segment of the spine the fourth forms the inferior segment

Morphologically, the component vertebrae are equivalent. Each vertebra consists of two essential parts an anterior segment, the body, and a posterior segment, the vertebral or neural arch, which completes the spinal foramen, the articulated series of which constitutes the vertebral

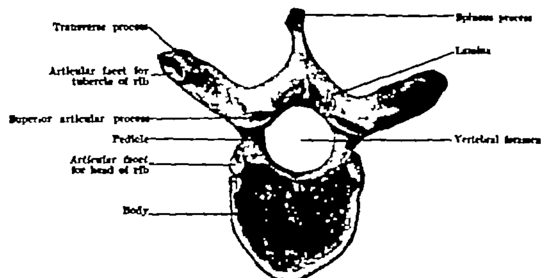


Fig. 15 Typical vertebra, sixth thoracic, from above. *(From Surgery of the Spine and Spinal Cord by Chas H Frazier—D Appleton-Century Co)*

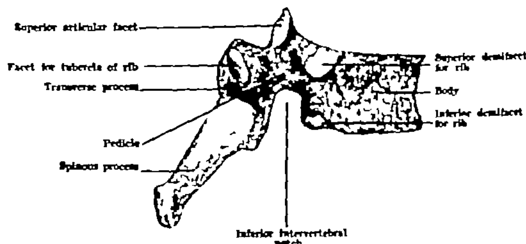


Fig. 16. Typical vertebra, sixth thoracic from side. *(From Surgery of the Spine and Spinal Cord by Chas H Frazier—D Appleton-Century Co)*

canal The neural arch has two pedicles two laminae and seven processes—four articular two transverse and one spinous The pedicles have vertebral notches above and below which with those of the vertebrae above and below form the intervertebral foramen The laminae are

TABLE A

TABLE SHOWING THE CHARACTERS OF TYPICAL VERTEBRAE OF EACH GROUP

(From *Gerrish's Anatomy* Lea & Febiger)

	Cervical	Thoracic	Lumbar
Bodies	Small transversely elongated sloped downward and forward, lipped laterally No costal facets.	Heart shaped. Deeper behind Nearly equal transversely and antero-posteriorly Costal facets	Large Elongated transversely No costal facets.
Pedicles	Pass outward and backward. Notches above and below nearly equal	Pass backward Inferior notches deeper than superior	Pass backward and slightly outward. Inferior notches deep.
Laminae	Long, slender flattened	Broad short, imbricated	Short deep and thick.
Spinous processes	Short, strong, bifid and highly horizontal.	Long, projecting downward and overlapping.	Quadrate horizontal of medium length.
Transverse processes	Short, slender directed outward and forward	Long, strong. Projecting outward and backward. Articulate with tubercles of ribs.	Rudimentary as "accessory process
Costal process	Slender flat, ossified to the vertebra and transverse process.	A separate bone (*i. e.*, a rib)	Ossified to vertebra. Flat, thin, "transverse process
Superior articular processes	Flat, directed upward and slightly backward.	Flat, directed backward and slightly outward.	Slightly concave directed inward and slightly backward
Inferior articular processes	Flat, directed downward and slightly forward	Flat, directed forward and slightly inward.	Slightly convex. Directed outward and slightly forward.
Spinal foramen	Large, triangular wide	Smaller, circular	Larger than in the thoracic Triangular Wide.

broad expansions from the pedicles fusing behind in the middle line, and prolonged at their junction into the spinous processes The transverse processes are outward projections from the points of junction of pedicles and laminae The articular processes comprise an upper and

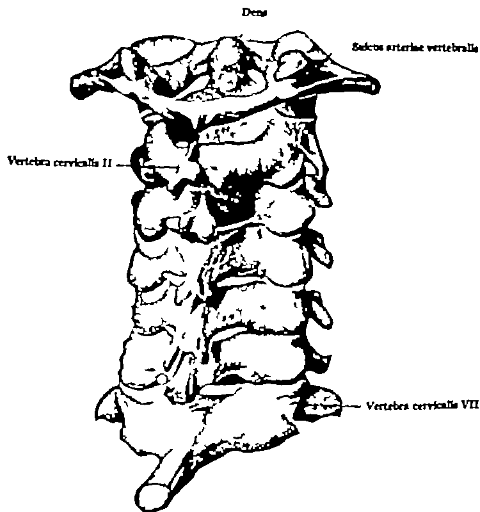


Fig. 17 Posterior view of the cervical vertebrae. *(Callender's Surgical Anatomy W. B. Saunders Co.)*

lower pair from the roots of the transverse processes and articulate with those of the vertebrae above and below

Characteristics of Peculiar Vertebrae

The Atlas The atlas or first cervical vertebra is so named because it supports the globe of the head Its chief peculiarities are that it has no body and no spinous process. It is ring like and consists of an anterior and a posterior arch and two lateral masses

The lateral masses are the large, solid portions of the atlas which support the weight of the head Each has two articular facets—one superior, the other inferior The superior facets are large in size and approach each other in front, but diverge behind Each forms a cup for

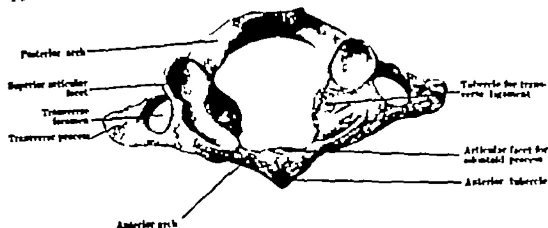


Fig. 18. Atlas, from above *(Surgery of the Spine and Spinal Cord by Chas H Frazier—D Appleton-Century Co)*

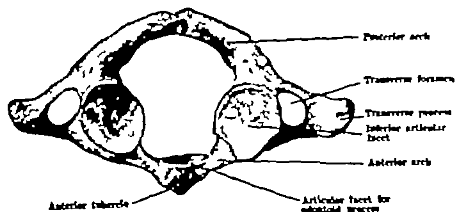


Fig. 19 Atlas, from below *(From Surgery of the Spine and Spinal Cord, by Chas H Frazier—D Appleton-Century Co)*

the corresponding condyle of the occipital bone, and is well adapted to the nodding movements of the head. The inferior articular facets are circular in form slightly convex, and directed downward and medial ward They articulate with the axis and permit the rotary movements of the head.

Directly below the medial margin of each superior facet there is a small tubercle to which the transverse atlantal ligament is attached This ligament stretches across the ring of the atlas dividing the vertebral foramen into two unequal parts The posterior part of this foramen is

of considerable size transmitting the medulla spinalis and its membranes It is much greater in size than is required for the transmission of the medulla spinalis and hence lateral displacement of the atlas may occur without compression of this structure The anterior or smaller portion of the vertebral canal receives the odontoid processes of the axis

The anterior arch which is much the weaker of the two arches, connects the antero-medial parts of the two lateral masses The anterior surface is convex, and at its center is the anterior tubercle where the longus colli muscles attach The posterior surface is concave and presents a circular articular facet (fovea dentis) for articulation with the odontoid process of the axis.

The posterior arch, which is by far the larger of the two arches, ends behind in the posterior tubercle It is from this tubercle or rudimentary spinous process that the recti capitis posteriores minores have their origin Behind and above, the posterior arch presents a rounded edge where the posterior atlantoöccipital membrane attaches Just behind each superior articular process is a groove (sulcus arteriae vertebralis) This groove represents the superior vertebral notch and serves for the transmission of the vertebral artery and the suboccipital (first spinal) nerve There are two shallow grooves on the under surface of the posterior arch behind the articular facets These are the inferior vertebral notches The lower border provides a point of attachment for the posterior atlantoäxial ligament which connects it with the axis The transverse processes project downward and lateralward from the lateral masses and are quite large To them are attached the muscles which assist in rotating the head

The Epistropheus or Axis The axis or second cervical vertebra is so named because it forms the pivot upon which the first vertebra carrying the head rotates. The most distinctive characteristic of this bone is the strong odontoid process which projects upward from its body

The body is deeper in front than behind and presents a median longitudinal ridge in front separating the two lateral depressions for the attachment of the longus colli muscles The undersurface is convex from side to side and concave from front to back

The odontoid process represents the body of the atlas fused with that of the axis It exhibits a slight constriction at the neck where it joins the

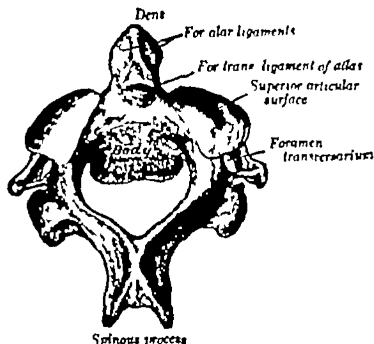


Fig. 20. Second cervical vertebra, or epistropheus, from above. *(From Gray's Anatomy Lea and Febiger Company)*

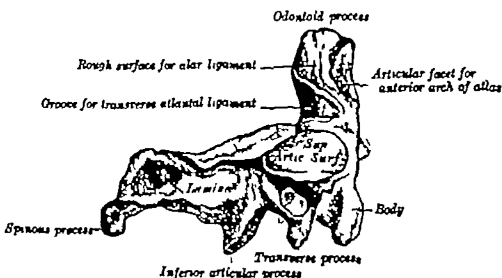


Fig. 21 Second cervical vertebra, epistropheus, or axis, from the side. *(From Gray's Anatomy Lea and Febiger Company)*



Fig. 22. Median sagittal section through the atlantoaxial (epistrophial) joint, schematized. (*Callender's Surgical Anatomy* W. B. Saunders Co.)

body The facet on its anterior surface is an oval or nearly circular facet for articulation with that on the anterior arch of the atlas On the back of its neck is a shallow groove for the transverse atlantal ligament, which keeps the process in position

The apex is rather pointed, and it is here that the apical odontoid ligament is attached Below the apex the process is somewhat enlarged and presents on either side a rough impression for the attachment of the alar ligament This ligament connects the occipital bone with the process

The pedicles are strong and coalesce in front with the sides of the body and the root of the odontoid process The laminae are strong and thick, and the vertebral foramen although large, is smaller than that of the atlas. The transverse processes are small and each ends in a single tubercle, and each is perforated by the foramen transversarium The spinous process is large and strong deeply channeled on its undersurface and presents a bifid extremity The inferior articular surfaces have the same direction as those of the other cervical vertebrae. The superior articular surfaces are slightly convex and round, directed upward and lateralward, and are supported on the body, pedicles and transverse processes The superior notches are shallow and lie behind the articular processes The inferior vertebral notches lie in front of the articular processes as in the other cervical vertebrae

The Vertebra Prominens The seventh cervical vertebra, otherwise called the vertebra prominens owes its name to its most distinctive characteristic—the existence of a long and prominent spinous process This process is nearly horizontal in direction, quite thick and not bifurcated It terminates in a tubercle to which the lower end of the ligamentum nuchae is attached

The transverse processes are of considerable size and these together with its transversely expanded body make this vertebra much greater in breadth than the preceding one The foramen transversarium is generally smaller on one or both sides than in the other cervical vertebrae It may, however be as large—sometimes double in size and it may even be absent The vertebral artery and vein usually pass in front of the transverse process of this vertebra, and not through the foramen. The anterior root of the transverse process occasionally attains considerable

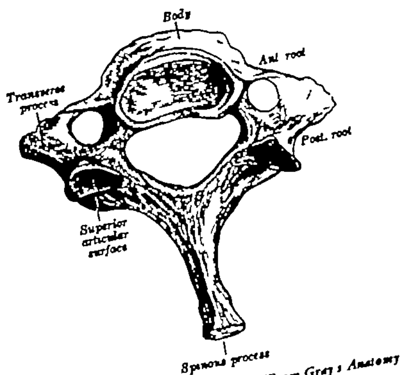


Fig. 23. Seventh cervical vertebra. (From Gray's Anatomy Lea and Febiger Company)

size and exists as a separate bone. This is known as a cervical rib

Peculiar Thoracic Vertebrae The *first, ninth, tenth, eleventh,* and *twelfth* thoracic vertebrae are distinguished from the other members of this group chiefly by the following modifications in their articular relations with the ribs

The First Thoracic Vertebra This vertebra is similar in general shape to the last cervical vertebra in that it is broad transversely and in that the length and direction of its spinous process are much the same On either side of the body of this vertebra there is an entire articular facet for the head of the first rib and a demifacet for the upper half of the head of the second rib The superior articular surfaces are directed backward and upward the transverse processes are long and the upper vertebral notches are deeper than those of the other thoracic vertebrae.

The Ninth Thoracic Vertebra The ninth thoracic vertebra sometimes has no demifacets below Occasionally it has two demifacets on either side and when this does occur the tenth thoracic vertebra has only demifacets on its upper surface

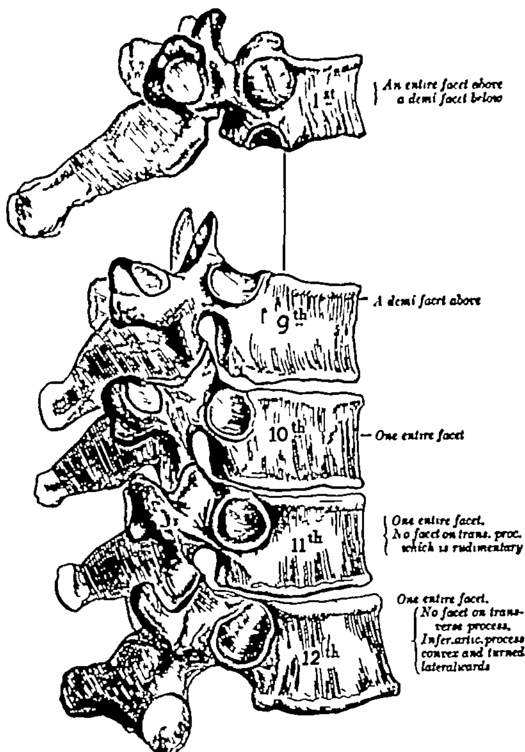


Fig. 24. Peculiar thoracic vertebrae. *(From Gray's Anatomy Lea and Febiger Company)*

The Tenth Thoracic Vertebra This vertebra has an entire articular facet on either side (except in those instances just mentioned) This facet lies well on the lateral surface of the pedicle The facet on the transverse process may be absent, and is usually quite small

The Eleventh and Twelfth Thoracic Vertebrae The twelfth thoracic vertebra is similar in general appearance to the adjoining lumbar segment. Its general characteristics are also quite similar to those of the eleventh thoracic vertebra. It may be distinguished however, because its inferior articular surfaces are convex and directed lateralward like those of the lumbar vertebrae The form of its body its spinous process and laminae also resemble the lumbar vertebrae. Its transverse process is subdivided into three elevations, the superior, the inferior and the lateral tubercles, which, in the lumbar vertebrae, are respectively the mammillary, accessory and transverse processes

Peculiar Lumbar Vertebrae

The Fifth Lumbar Vertebra The fifth lumbar vertebra is distinguished by its body which is deeper in front than behind thus matching the prominence of the sacrovertebral articulation The upper surface of the body of this vertebra is slightly heart shaped in outline corresponding with the body of the vertebra above Its inferior surface is transversely elongated in form and is similar to the opposed surface of the sacrum The spinous process of this vertebra is smaller than those of the other lumbar vertebrae Its transverse processes are barely perceptible and spring from the body as well as the pedicles.

The Sacrum (os sacrum)

The sacrum is triangular in form with the expanded base above and the apex below and is the last segment of the vertebral column, at the upper and back part of the pelvic cavity It is inserted between the two pelvic bones like a wedge. Its apex articulates with the coccyx its base with the last lumbar vertebra It is placed obliquely with its base projecting forward and forming the prominent sacrovertebral angle when articulated with the last lumbar vertebra. Its central part is projected backward, thus giving an increased capacity to the pelvic cavity

The five sacral segments of which the sacrum is composed remain distinct and are separated by thin intervertebral discs until about the fifteenth year Between the fifteenth and twentieth year they undergo fusion, but, however, distinct remains of the lines of union are usually present until the twenty fifth year and bony ridges subsequently mark

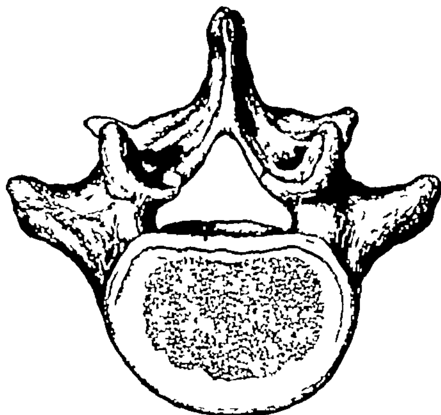


Fig. 25 Fifth lumbar vertebra, from above. *(From Gray's Anatomy Lea and Febiger Company)*

off the original segments The transverse processes and rib elements of the sacral vertebrae also undergo fusion and form the lateral masses

The anterior or pelvic surface of the sacrum is slightly concave at the sides and top In the female the curve is more acute below the third segment. The anterior surface of the sacrum is crossed by four transverse ridges These are the lines of union of the fused sacral vertebrae The portions of bone between the ridges are the bodies of the sacral vertebrae The body of the first segment is the largest and each successive one is smaller than the one next above it They are concave in front and convex behind and are curved so as to accommodate themselves to the

form of the sacrum. Laterally, at the end of the ridges, are the anterior sacral foramina There are four of these, and usually they decrease in size, as they approach the coccyx.

Not infrequently however the second and third openings are larger than the first, this being due chiefly to the outward sloping of their

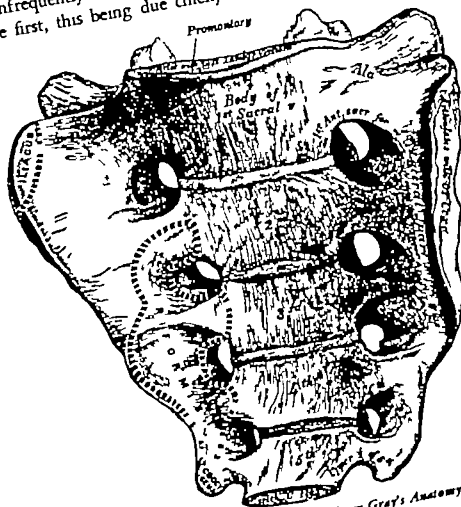


Fig. 26. Sacrum, pelvic surface. (*From Gray's Anatomy Lea and Febiger Company*)

grooved lateral walls These apertures give exit to the anterior divisions of the sacral nerves and entrance to the lateral sacral arteries

Just lateral to these foramina are the lateral parts of the sacrum In early life each of these consist of five separate segments In the adult however they are blended with the bodies and with each other Each of these lateral parts is traversed by four broad shallow grooves These lodge the anterior divisions of the sacral nerves and are separated by

prominent ridges of bone which give origin to the piriformis muscle The posterior surface is rough and convex from above downward, and is modeled by a series of projections more or less fused into a common ridge The crista sacralis media or middle sacral crest is surmounted by three or four tubercles These are the rudimentary spinous processes of the upper three or four sacral vertebrae On either side of the crest is a shallow groove, the sacral groove The floor of this groove is formed by the united laminae of the corresponding vertebrae From this groove arises the multifidus On the lateral aspect of the sacral groove is a series of tubercles These are produced by the fusion of the articular processes, and form the indistinct sacral vertebrae Occasionally, those of the fourth do not meet behind, and thus a hiatus is formed in the posterior wall of the sacral canal

Below the linear series of tubercles which form the sacral articular crest, the tubercles are prolonged downward into diverging prominent processes—the sacral cornua, which bind the incompletely closed vertebral canal and bear the inferior articular facets of the fifth sacral vertebra for articulation with the coccyx. Just lateral to the articular processes are the four posterior sacral foramina, somewhat smaller than the anterior processes These transmit the posterior divisions of the sacral nerves Just lateral to the posterior sacral foramina is a series of tubercles representing the transverse processes of the sacral vertebrae and forming the lateral crest of the sacrum The transverse processes of the first and second sacral vertebrae give attachment to the horizontal parts of the posterior sacroiliac ligament, while the transverse tubercles of the third vertebra give attachment to the oblique fasciculi of the posterior sacroiliac ligaments and the tubercles of the fourth and fifth vertebrae give attachment to the sacrotuberous ligaments

The Base of the Sacrum (*Basis oss sacri*) The base of the sacrum or the expanded upper surface of the bone includes the medially situated body and the lateral fan shaped expansions or the alae. In the middle is a large oval articular surface, which articulates with the fifth lumbar vertebra through the medium of an intervertebral disc Just behind this is the large triangular orifice of the sacral canal This canal is completed by the laminae and spinous process of the first sacral vertebra

Overhanging the concavity of the posterior pelvic wall is the sharp, anterior margin of the body of the sacrum This constitutes the promontory of the sacrum. The superior articular processes are oval, concave, and directed back and medialward and are quite similar to the superior articular processes of the lumbar vertebrae. They are attached to the body of the first sacral vertebra, and to the alae, by short thick pedicles. The ala sacralis or wing like mass, which broadens out from the sides of the body, constitute the upper surface of the lateral mass The lateral masses represent a fusion of the costal elements pedicles and their transverse processes

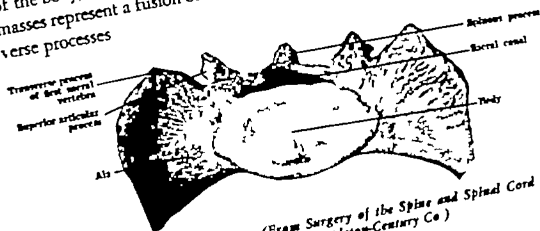


Fig. 27 Sacrum, from above. (*From Surgery of the Spine and Spinal Cord by Chas H Frazier—D Appleton-Century Co*)

The sacral canal runs through the greater part of the bone, and is compressed from the front and enclosed by the short pedicles and the fused sloping laminae It diminishes in size in its descent and at the level of the third or fourth sacral segment loses its posterior wall in consequence of the failure of the laminae to unite It conveys the sacral nerves, and its walls are perforated by the anterior and posterior sacral foramina through which these nerves pass out

The Lateral Surface The lateral surface of the sacrum is broad above and tapers sharply to a thin edge below the level of the third segment It is somewhat triangular The upper half of the lateral surface presents the auricular surface This is covered with cartilage for the articulation with the ilium Behind it is the sacral tuberosity on which there are three deep uneven impressions where the posterior sacroiliac ligament attaches. The lower half of the lateral surface ends in a projection called the inferior lateral angle Just medial to this angle is a notch which is

converted into a foramen by the transverse processes of the first segment of the coccyx Through this passes the anterior division of the fifth sacral nerve

The thin lower half of the lateral surface also gives attachment to the sacrospinous and sacrotuberous ligaments and to some fibers of the coccygeus in front and the glutaeus maximus behind The apex of the sacrum at its lower end is formed by the anterior surface of the small

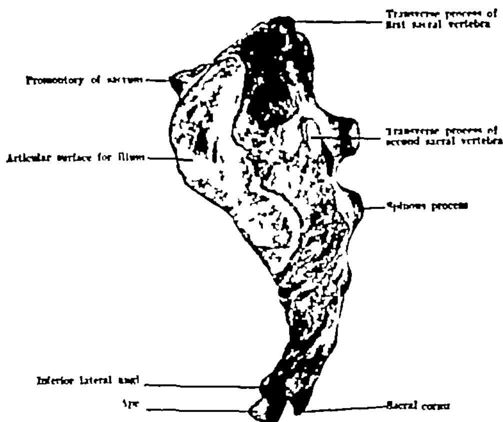


Fig. 28. Sacrum, lateral aspect. *(From Surgery of the Spine and Spinal Cord by Chas H Frazier—D Appleton-Century Co)*

body of the fifth sacral vertebra and articulates with the coccyx through the medium of an intervertebral disc. It is directed downward, and its articulating facet is oval

Differences in the Male and Female Sacrum The differences in the male and female sacrum are quite apparent. In the female the sacrum is shorter and wider than in the male and presents a less regular curve—the lower half forming a greater angle with the upper half, and having more curvature than the upper half which is nearly straight The concavity in the male is deeper and more uniform than in the female where

the anterior surface is almost flat from the promontory to the middle of the third segment, from which level to the apex the curve is more acute The sacrum is also directed more obliquely backward in the female than in the male, thus increasing the size of the pelvic cavity and rendering the sacral vertebral angle more prominent.



Fig. 29 Coccyx. *(From Gray's Anatomy Lea and Febiger Company)*

The Coccyx (os coccygis) This bone is usually formed of four, and sometimes five, rudimentary vertebrae Occasionally the number is reduced to three A rudimentary body and articular and transverse processes can be traced throughout the first three segments which are destitute of pedicles laminae, and spinous processes The first of these segments is the largest and resembles the lowest sacral vertebra—and often exists as a separate vertebra Often after middle life, all the segments are fused However the first coccygeal vertebra quite frequently

remains separate, fusing neither with the second nor with the sacrum

The anterior surface of the coccyx is slightly concave and marked with three transverse grooves which indicate the junction of the different segments To it is attached the anterior sacrococcygeal ligament and the levator ani which helps support the rectum Its posterior surface is convex and marked by transverse grooves similar to those on the anterior surface However, on either side of this surface, there is a linear row of tubercles These are the rudimentary articular processes of the coccygeal vertebrae

Those of the superior pair are quite large and are called the coccygeal cornua They articulate with the cornua of the sacrum and complete the foramen for the transmission of the posterior division of the fifth sacral nerve The base of the coccyx has an oval surface for the articulation with the sacrum The apex is rounded and to it is attached the tendon of the sphincter ani externus The lateral borders of the coccyx are thin and present a series of small eminences which correspond to the transverse processes of the coccygeal vertebrae The borders of the coccyx give attachment on either side to the sacrotuberous and sacrospinous ligaments to the glutaeus maximus behind the ligaments and to the coccygeus in front of them

The Articulations of the Vertebral Column

There are two sets of articulations between the vertebrae

1 Those between the bodies of the vertebrae which are amphiarthrodial

2. Those between the articular processes These are connected by ligaments and are true arthrodial diarthroses

ARTICULATIONS BETWEEN THE BODIES OF THE VERTEBRAE

1 The Intervertebral Discs There are 23 intervertebral discs uniting the vertebrae above the sacrum Each consists of an external tough fibrous portion and an internal spongy elastic, somewhat pulpy portion, with a central synovial cavity This latter is the nucleus pulposus It represents the modified remains of the notocord and is most often

eccentric in its position, lying mostly behind the middle of the disc. It may, however, lie centrally and occasionally it lies in the anterior part of the disc. The aggregate thicknesses of all the discs is about one fifth that of all the vertebrae above the sacrum

Structurally, the entire disc is composed of fibrocartilage arranged in more or less concentrically disposed lamellae—except for the super

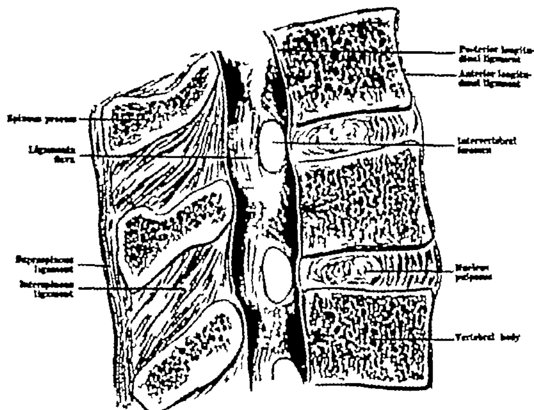


Fig. 30. Sagittal section of lumbar spine. *(From Surgery of the Spine and Spinal Cord by Chas H Frazier—D Appleton-Century Co)*

ficial portion, and the central spongy pulp or nucleus pulposus The latter consists of a fine fibrous matrix containing angular cells united to form a reticular structure

Functionally the intervertebral fibrocartilages form important shock absorbers and give elasticity to the spinal column The highly elastic nucleus pulposus under pressure becomes flatter and broader, and pushes the more resistant fibrous laminae outward in all directions

In the past decade, the intervertebral discs have become of great importance surgically for it has been found that they are often the

offending factor in low back pain (See Chapter IX on Low Back Pain—And Affections of the Lower Back)

2. The Anterior Longitudinal Ligament—*also called The Anterior Common Ligament* This is a strong band of fibers lying over the anterior portions of the vertebral bodies and extending the entire length of the spinal column It is continued above as the anterior atlantoöccipital

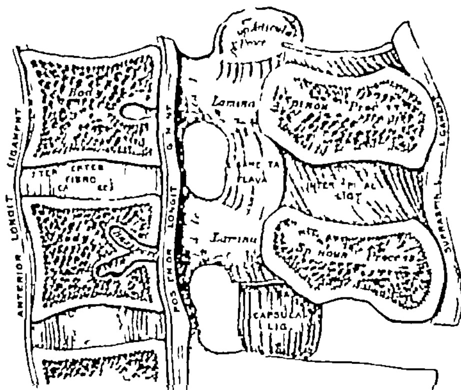


Fig. 31 Median sagittal section of two lumbar vertebrae and their ligaments. *(From Gray's Anatomy Lea and Febiger Company)*

and anterior atlantoäxial ligaments and below as the anterior sacrococcygeal ligament. Its function is partly to limit the extension of the spine

3 The Posterior Longitudinal Ligament—*often called The Posterior Common Ligament* This lies within the vertebral canal on the dorsal surfaces of the vertebral bodies and extends the length of the spinal column being continuous above with the posterior occipitoaxial ligament.

ARTICULATIONS OF THE VERTEBRAL ARCHES

These joints are of the arthrodial variety and are enveloped by capsules lined by synovial membranes The laminae, transverse and spinous processes are connected by ligaments, as follows

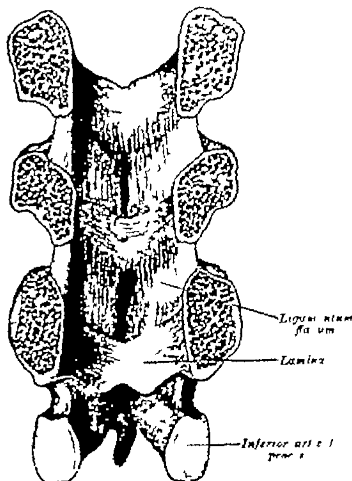


Fig. 32. The ligamenta flava of the lumbar region. Anterior aspect. *(From Gray's Anatomy Lea and Febiger Company)*

1 The Ligamenta Flava (Ligamenta Subflava) These connect the laminae of adjacent vertebrae from the axis to the first segment of the sacrum. They consist of yellow elastic tissue, and because of their marked elasticity serve to preserve the upright posture of the body They also aid the vertebral column in resuming an upright posture after flexion.

2. The Interspinous Ligaments These ligaments are fibroelastic

membranous sheaths and extend between the adjacent borders of the spinous processes

3 The Supraspinous Ligament This is a continuous ligamentous band over the tips of the spinous processes, and connects the apices of the spinous processes from the seventh cervical vertebra to the sacrum Above it is continued as the ligamentum nuchae

4 The Ligamentum Nuchae This is a fibrous membrane, and in the neck represents the supraspinous ligaments of the lower vertebrae It extends from the spinous process of the seventh cervical vertebra to the external occipital protruberance and median nuchal line In man it is merely a rudimentary structure

5 The Intertransverse Ligaments The structures of these ligaments are such that they cannot be considered as definite ligaments but rather as intermuscular septa They are interposed between the transverse processes

ARTICULATIONS OF THE ATLAS WITH THE AXIS OR EPISTROPHEUS

The articulations of the atlas with the axis comprise no fewer than four distinct joints The ligaments which connect these bones are

1 The Anterior Atlantoäxial Ligament This is a strong membrane fastened above to the border of the anterior arch of the atlas, and below to the front of the body of the axis

2 The Posterior Atlantoäxial Ligament This is a broad membrane attached at its superior end to the lower border of the posterior arch of the atlas Below it is attached to the edges of the laminae of the axis

3 The Two Articular Capsules These connect the margins of the lateral masses of the atlas with those of the posterior articular surfaces of the axis

4 The Transverse Ligament of the Axis This is a strong band like membrane which arches across the ring of the atlas and retains the odontoid process in contact with the anterior arch It divides the ring of the atlas into two unequal parts—a posterior or larger portion which serves for the transmission of the medulla spinalis its membranes and the accessory nerves and the smaller or anterior portion which contains the odontoid process

All four of the joints between the axis and the atlas have a synovial membrane

Movements The movement in this articulation allows for the rotation of the atlas upon the axis and, of course of the skull with it The amount of rotation is limited primarily by the alar ligaments.

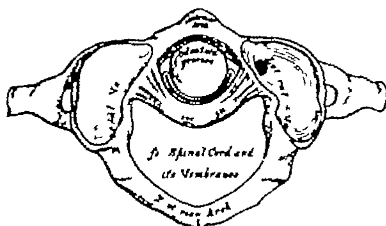


Fig. 33. Articulation between odontoid process and atlas. *(From Gray's Anatomy Lea and Febiger Company)*

The Articulation of the Vertebral Column With the Cranium

The ligaments which connect the vertebral column with the cranium are of two types

1 Those which unite the atlas with the occipital bone.
2 Those which connect the axis with the occipital bone

THE ATLANTOÖCCIPITAL ARTICULATION

This articulation or joint is sometimes referred to as the upper articulation of the head It comprises four articulating surfaces two being furnished by the condyles of the occipital bone, and two by the lateral masses of the axis These are condyloid joints and the ligaments connecting the bones are

1 The Anterior Atlantoöccipital Membrane This membrane or ligament is quite broad and is composed of densely woven fibers It passes between the anterior margin of the foramen magnum above and the upper border of the anterior arch of the atlas below In front it is strengthened by a strong rounded cord which connects the tubercle on the anterior arch of the axis with the basilar part of the occipital bone

2. The Posterior Atlantooccipital Membrane This membrane or ligament is connected above to the posterior margin of the foramen magnum and inferiorly to the upper border of the posterior arch of the axis In front it is in relation with the dura mater of the vertebral canal while behind it is in relation with the recti capitis posteriores minores and the obliqui capitis superiores

3 Two Lateral Atlantoöccipital Membranes These ligaments are directed obliquely upward and medialward Above they are attached to the jugular process of the occipital bone, below to the bases of the transverse process of the atlas

4 Two Articular Capsules These capsules surround the condyles of the occipital bone and connect them with the articular processes of the atlas

Movements Extension and flexion are the motions permitted by this joint Thus we have the ordinary movements of forward and backward nodding and the slight lateral motion of the head to one side or the other

LIGAMENTS CONNECTING THE OCCIPITAL BONE WITH THE AXIS

There are three ligaments performing this function

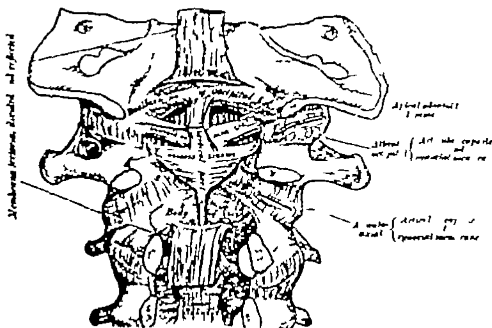


Fig. 34 Membrana tectoria, transverse and alar ligaments. (*From Gray's Anatomy Lea and Febiger Company*)

1 The Apical Odontoid Ligament This lies in the triangular interval between the two alar ligaments. It extends from the tip of the odontoid process to the anterior margin of the foramen magnum It is a rudimentary intervertebral fibrocartilage Quite often traces of the notocord are found to persist within it.

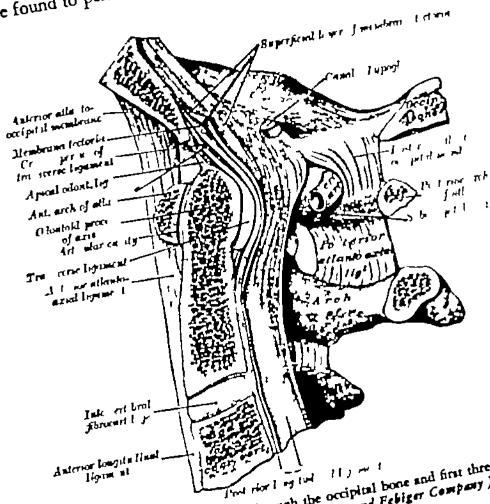


Fig 35 Median sagittal section through the occipital bone and first three cervical vertebrae (From Gray's Anatomy Lea and Febiger Company)

2. The Alar Ligaments These are strong rounded ligaments and arise one on either side of the upper part of the odontoid process They pass upward and lateralward, and are inserted into the medial sides of the condyles of the occipital bone In action they tend to limit rotation of the cranium and are quite often called check ligaments

3 The Membrana Tectoria or Occipitoāxial Ligament This lies within the vertebral canal and covers the odontoid process It arises

below from the posterior surface of the body of the axis, and is attached above to the basilar groove of the occipital bone in front of the foramen magnum

THE SACROCOCCYGEAL ARTICULATION

This is an amphiarthrodial joint formed between the oval surfaces at the apex of the sacrum at the base of the coccyx and connected by the following ligaments

1 The Anterior Sacrococcygeal Ligament This ligament is connected to the anterior surface of the sacrum and to the front of the coccyx

2. The Posterior Sacrococcygeal Ligament This ligament arises from the margin of the lower orifice of the sacral canal and is inserted into the posterior surface of the coccyx It completes the lower and back part of the sacral canal

3 The Lateral Sacrococcygeal Ligament This ligament connects the transverse process of the coccyx with the lateral angle of the sacrum

4 The Interarticular Ligaments These ligaments unite the cornua of the two bones There is a disc of fibrocartilage between the surfaces of the sacrum and the coccyx somewhat different from that between the bodies of the vertebrae in that its center is firmer in texture

Movements Between the sacrum and the coccyx movement is forward and backward and very limited in extent During pregnancy the extent of this movement increases

The Nerves and Blood Supply of the Spine

Nerves The tiny nerves which supply the spine arise from the posterior primary division of the spinal nerves

Blood Supply The small arteries which supply the spine are derived from several sources In the cervical region the branches which supply the spine are derived from the occipital the deep cervical the vertebral and the ascending cervical artery In the thoracic lumbar and sacral regions the branches which supply the spine are the intercostal the lumbar and the lateral sacral arteries

Many of these small arteries which supply the vertebral bodies and

1 The Apical Odontoid Ligament This lies in the triangular interval between the two alar ligaments. It extends from the tip of the odontoid process to the anterior margin of the foramen magnum It is a rudimentary intervertebral fibrocartilage. Quite often traces of the notocord are found to persist within it.

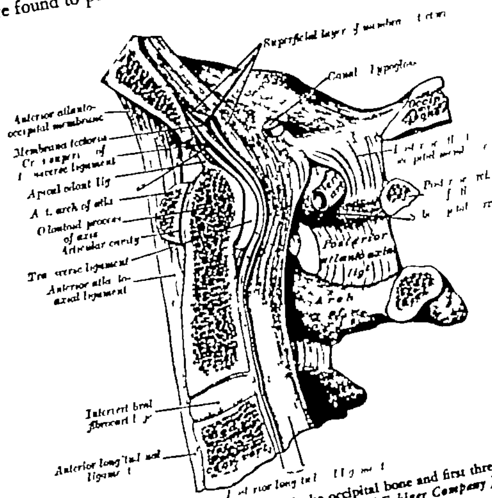


Fig 35 Median sagittal section through the occipital bone and first three cervical vertebrae (*From Gray's Anatomy Lea and Febiger Company*)

2. The Alar Ligaments These are strong rounded ligaments and arise one on either side of the upper part of the odontoid process. They pass upward and lateralward and are inserted into the medial sides of the condyles of the occipital bone In action they tend to limit rotation of the cranium and are quite often called check ligaments

3 The Membrana Tectoria or Occipitoaxial Ligament This lies within the vertebral canal and covers the odontoid process It arises

below from the posterior surface of the body of the axis, and is attached above to the basilar groove of the occipital bone in front of the foramen magnum

THE SACROCOCCYGEAL ARTICULATION

This is an amphiarthrodial joint, formed between the oval surfaces at the apex of the sacrum at the base of the coccyx and connected by the following ligaments

1 The Anterior Sacrococcygeal Ligament This ligament is connected to the anterior surface of the sacrum and to the front of the coccyx

2. The Posterior Sacrococcygeal Ligament This ligament arises from the margin of the lower orifice of the sacral canal and is inserted into the posterior surface of the coccyx It completes the lower and back part of the sacral canal

3 The Lateral Sacrococcygeal Ligament This ligament connects the transverse process of the coccyx with the lateral angle of the sacrum

4 The Interarticular Ligaments These ligaments unite the cornua of the two bones There is a disc of fibrocartilage between the surfaces of the sacrum and the coccyx somewhat different from that between the bodies of the vertebrae, in that its center is firmer in texture

Movements Between the sacrum and the coccyx movement is forward and backward and very limited in extent During pregnancy the extent of this movement increases

The Nerves and Blood Supply of the Spine

Nerves The tiny nerves which supply the spine arise from the posterior primary division of the spinal nerves

Blood Supply The small arteries which supply the spine are derived from several sources In the cervical region the branches which supply the spine are derived from the occipital the deep cervical the vertebral and the ascending cervical artery In the thoracic, lumbar and sacral regions the branches which supply the spine are the intercostal, the lumbar and the lateral sacral arteries

Many of these small arteries which supply the vertebral bodies and

ligaments enter the body by the foramen situated on either side of the midline Other small arteries come from the anastomatic arches formed by the spinal branches over the posterior surface of the body and enter the body from the dorsal surface The spinal branches give off tiny arteries which enter the anterior surfaces of the vertebral arches, and supply the articular processes and the capsules Other small branches are derived from the deep muscular branches of the lumbar and intercostal arteries

Veins of the Spine The veins form most complicated plexuses situated within and without the spinal cord The plexuses are

1 The anterior external vertebral plexuses
2. The anterior longitudinal vertebral plexuses
3 The posterior longitudinal vertebral plexuses
4 The posterior external vertebral plexuses
5 The venae basivertebrales into which some of the large venous channels terminate posteriorly

The intervertebral veins carry off the greater portion of the blood gathered from the vertebrae and the spinal cord After passing through the intervertebral foramen these veins open into the vertebral veins in the cervical region into the intercostal veins in the thoracic region into the lumbar veins in the lumbar region and into the lateral sacral veins in the sacral region

Fascia of the Spine

The vertebral fascia is an extension downward of the posterior portion of the cervical fascia. It stretches from the spinous processes of the thoracic vertebrae to the angles of the ribs covering in the deep vertical muscles of the back passing in front of the seratus posterior superior and becoming continuous below with the lumbar fascia

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CHAPTER IV

Laminectomy

Laminectomy is an operative procedure which consists of resection of portions of the laminae from one or both sides of the neural arches of one or several vertebrae The name of MacEwen should always be associated with this operation for it was he who first introduced it as an orderly and useful procedure.

When the operation is performed on both aspects of the neural arch with the removal of the spinous processes, the term *bilateral laminectomy* is applied when on one side only, *hemilaminectomy* or *unilateral laminectomy*)

The proper operating instruments, the proper operating table, and the position of the patient upon this table, are of no little importance It is our belief that the Albee-Comper Orthopedic Table offers the best means available at the present time for arranging and maintaining the patient in the proper position for this operation

Indications Resection of the vertebral laminae is indicated chiefly for the purpose of decompression, but occasionally it is resorted to for exploratory purposes or for the following specific, or allied, conditions of the vertebrae, cord and membranes

1 Simple dislocations
2 New growths
3 Pressure symptoms from angulation of the spine in Pott s disease Kummell s disease, etc
4 Nerve root work
5 Removal of tumors foreign bodies, bullets, shrapnel etc.
6 Intervertebral Disc Pathology (Protruding disc, ruptured nucleus pulposus hypertrophied ligamentum flava.)

Localization In preparation for all intraspinal operations, some means for the accurate localization of at least one spinous process should

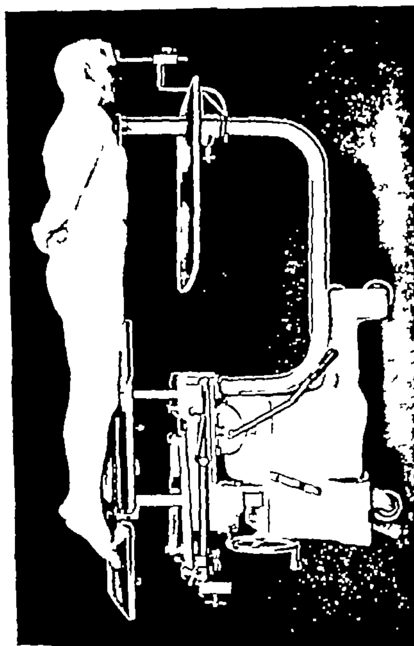


Fig. 36. Albee-Comper table showing patient in position for upper thoracic and cervical spine operations. (*Albee-Comper Fracture Table (booklet) Comper Mfg Company Pittsfield Mass.*)

be adopted. This is probably best accomplished by selecting for identification the spinous process about the middle of the contemplated laminectomy

The use of the seventh cervical or vertebra prominens as a starting point in the cervicothoracic region, and the last thoracic vertebra in the thoracolumbar region is advisable. The successive spines are counted from the landmark until the desired one is reached. This is then marked in the following manner A strip of metal or other opaque substance is fastened to the skin at the desired level, and a roentgenogram, preferably a lateral one is made. The latter will show with precision whether the first calculation was correct

When the identification of a given spinous process has thus been determined the overlying skin at the spot where the metal has been placed is marked indelibly with caustic silver or a suture superficially placed in the skin Unless these precautions are taken there will be danger of mistakes in localization in cases without kyphosis—particularly in heavy patients

Preoperative Preparation On the day before—or two days before—the operation, the operative site and a generous area of the surrounding skin is shaved and scrubbed vigorously with green soap All traces of the soap are removed with water and the site is washed with benzine to remove as much surface oil or grease as possible. A 50 per cent solution of alcohol is then applied After this dries the region is painted with a 3½ per cent strength tincture of iodine and covered with sterile towels In the operating room these towels are removed, and the site is again painted with the same strength of tincture of iodine One hour before operation, an adult patient is given 10 mg (1/6 grain) of morphine sulfate, and 0 45 mg (1/150 grain) of atropine sulfate. Children are given doses in proportion

Operative Considerations The authors do not favor the no hand contact technic of Lane or the procedure of clamping towels or other material to the wound edges by which in his opinion as much or more is lost than gained. This is true not only in spinal surgery, but in all bone surgery where an excess of instrumentation is often necessary The skin edge of the wound is likely to be devitalized by the crushing of the clamps and the drying effect produced by the fabric We believe

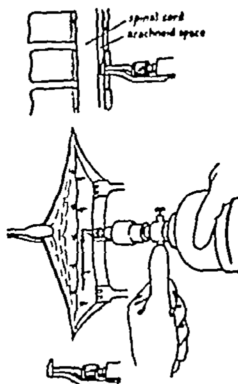


Fig. 37 New oscillating electrical laminatome attachment to Albee bone mill guard is introduced into arachnoid space and a path is cut through the desired number of laminae above and below this point. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

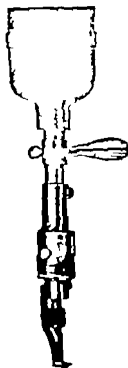


Fig. 38. Albee's oscillating saw attachment for use in laminectomy *(By courtesy of Kny-Scheerer Company)*

that the operative hazard of infection is minimized when the following points are observed

1 Thorough preoperative preparation
2 Adequate approach with minimum rough retraction
3 Reasonable speed with minimum traumatization
4 Use of as little absorbable suture material as will answer for both the closure of the soft parts and the fixation of the bony element.
5 Avoidance of hematoma by a continuous length link suture of #1 chromic catgut. Such a ligature brings pressure upon the soft tissues in every dimension and eliminates multiple knots
6 Closure of the skin by a continuous link suture of #0 plain catgut
7 Thorough puddling of the suture holes, as well as the line of incision by smashing 3½ per cent tincture of iodine into them by repeated sharp blows with the gauze of a sponge stick "
8 Proper immobilization

Anesthesia In most instances the operation is carried out under general anesthesia, using nitrous oxide-oxygen-ether as the anesthetic. There are some, however who recommend the intratracheal insufflation method of Meltzer Occasionally local anesthesia should be resorted to notably when the patient s vitality is greated exhausted by disease, and when as in trauma of the lower cervical cord with paralysis of the inter spinal and abdominal muscles there is a great risk of pneumonia There is nothing special to be stated about anesthesia in spinal surgery, except that spinal anesthesia about the mid-dorsal region, has proved unsatisfactory in the authors experience

Bilateral Laminectomy

This is the procedure employed by the majority of surgeons doing spinal surgery at the present time Since it entails the removal of an unnecessarily large amount of bone, it has a tendency to weaken the spinal column, and is therefore, a less desirable procedure—in the opinion of the authors—than that of hemilaminectomy particularly in the cervical region where the bone structure is frail However where a wide exposure of the spinal cord is necessary a bilateral operation is the one

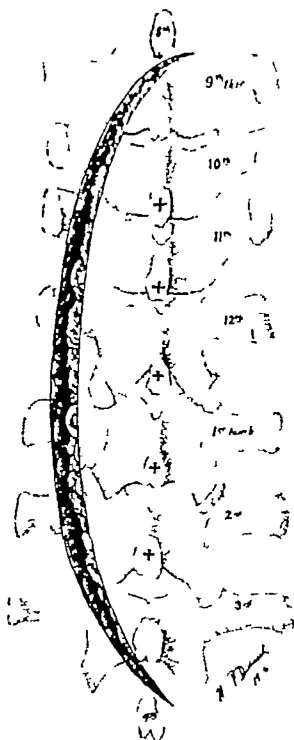


Fig. 39 Length and relation of the semilunar incision in the skin to the spinous processes for a laminectomy to include the tenth, eleventh, and twelfth thoracic and first and second lumbar vertebrae.



Fig. 40. Technic of laminectomy. The cutaneous flap is reflected, showing the oval incision in the intervertebral fascia beginning one spinous process above and one below the contemplated opening in the spinal canal.

of choice, and, if necessary, weakness can be overcome by placing tibial bone grafts on either side of the laminectomy gutter

Technic After exposure of the field of the operation by a generous incision—generous enough to permit the operation to be done easily—and by separating all soft parts from both sides of the spinous processes they are removed *in toto* from the vertebrae selected for operation down to the neural arches, by means of a large rongeur or bone forceps The laminae in midline under the stumps of the spinous processes are then removed by spinal rongeurs or the Albee electrically-driven lamina tome as the surgeon decides

Holes for the admission of the laminatome are made by the spinal rongeurs on either side of the spinous processes stumps, and parallel cuts sufficiently far apart are made by the laminatome so that the inter vening strip of bone consisting of the bases of the spinous processes and the adjoining portions of the laminae can be removed as in the unilateral procedure, or the bases of the neural arches and the stumps of the spinous processes may be partially removed by one cut of the laminatome, and then the opening enlarged laterally by means of the rongeur bone cutters to expose the cord or its membranes sufficiently

Hemostasis in this operation is of prime importance and can hardly be stressed too much, and especially if the dura is to be opened Trauma, and its prevention is likewise of equal importance It is the authors belief that so-called spinal shock is caused not by the escape of the cerebrospinal fluid—which has received the credit for this for many years—but rather to improper hemostasis and unnecessary trauma.

After completion of this operation the muscles are sutured to the perispinous and interspinous tissues, with interrupted sutures of #1 chromic catgut The use of two three, or even four interrupted small kangeroo tendon sutures in this layer is of added value in adding strength to the closure The aponeurosis is closed with a continuous suture of #1 chromic catgut, and the skin with a continuous suture of #1 plain cat gut. No drainage is employed A large firm sterile dressing is applied and retained by adhesive strips and a binder (plaster of paris is rarely used), and the patient is kept in a lateral or prone position resting on an air or water mattress for from five to eight weeks usually Of course no general rule can be laid down as to the period of enforced rest in bed

for in many instances, the patient is already paralyzed before the operation and the question of his becoming ambulant depends more upon the paralysis than on how many laminae, etc., were removed at the operation

After Care The condition of the patient after the operation is seldom one to give alarm. Although the pulse may be accelerated, the temperature subnormal, it is quite unusual to have to treat a patient for the condition of surgical shock or collapse In most cases with the exception of morphine for the relief of pain, little or no medication is required, and because the sphincters are frequently paralyzed, and since the dressing may become soiled by leakage, proctoclysis is seldom employed.

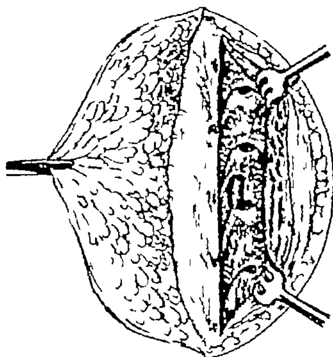


Fig. 41 Right hemilaminectomy Erector spinae muscles retracted, exposing neural arches of vertebrae. A section has been removed from one lamina by means of bone forceps and rongeur to permit of introduction of the author's laminatome.

Hemilaminectomy

In any condition where there is a conflicting weakness of the spinal column the authors believe that hemilaminectomy is preferable to bilateral laminectomy In the first place the spine is not weakened to nearly the degree that it would be by bilateral laminectomy Secondly

it preserves the spinous processes thereby permitting the easy insertion of a bone graft at once or at some future date if such a delay is necessitated by some such condition as a fracture of the spine which fails to unite firmly (In several instances the authors have found it necessary to insert the bone graft on account of failure of union) In the third place in the condition known as Kümmell s disease (which, of course is not

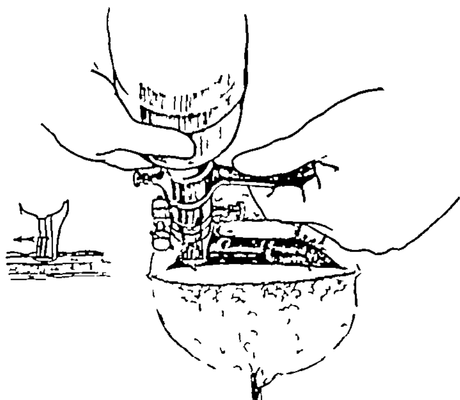
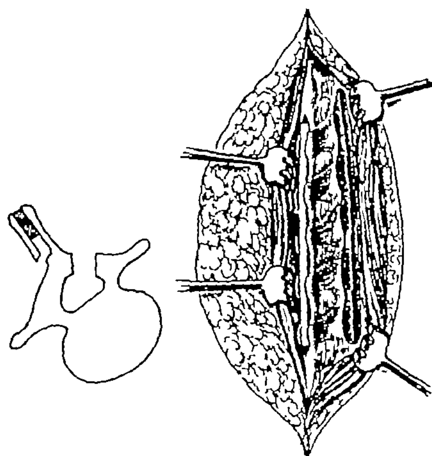


Fig. 42. Right hemilaminectomy The senior author s motor-driven laminatome has cut a path through the two laminae shown in the upper portion of the field. The instrument will next be reversed to cut through the laminae in the lower part of the field, along the dotted lines. The details of the laminatome are shown in the small upper figure. *(From Orthopaedic and Reconstruction Surgery by F H Albee W B Saunders Co)*

actually a disease, but a microscopic disintegration or a comminuted condition of the vertebral body severe enough to cause compression of the cord) a combined operation would be indicated—for decompression, and for support and immobilization to prevent further deformity Again in a case of Pott s disease complicated by compression of the cord similar conditions are present and should be met by a combined



3. Right hemilaminectomy of five vertebrae with a tibial bone-graft inserted ›e corresponding *spinous processes.* The *spinous processes are split* and the broken on opposite side (left) and graft inserted as for Pott's disease at the f the hemilaminectomy or later if found necessary to support or immobilize me.

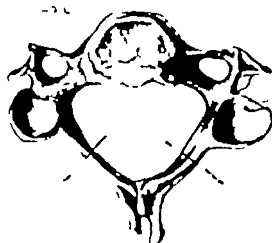


Fig. 44 A cervical vertebra. The broken lines show the amount of bone removed in order to widely open the spinal canal. (Elsberg.) *(Orthopaedic and Reconstruction Surgery by F H Albee W B Saunders Co., Philadelphia and London 1921)*

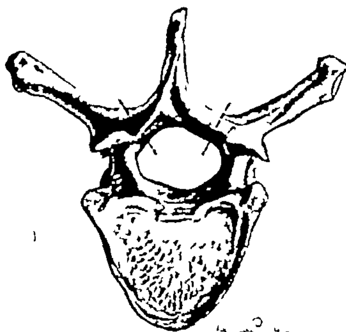


Fig. 45 A dorsal vertebra (broken lines as in Fig. 44) (Elsberg.) *(Orthopaedic and Reconstruction Surgery by F H Albee W B Saunders Co 1921)*

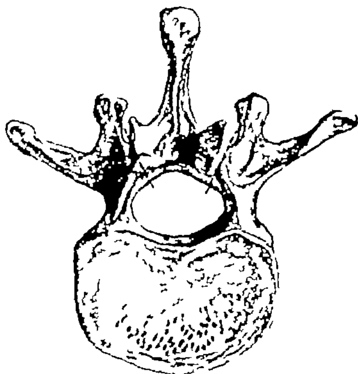


Fig. 46. A lumbar vertebra. (Elsberg.) *(Orthopaedic and Reconstruction Surgery by F H Albee W B Saunders Co., 1921)*

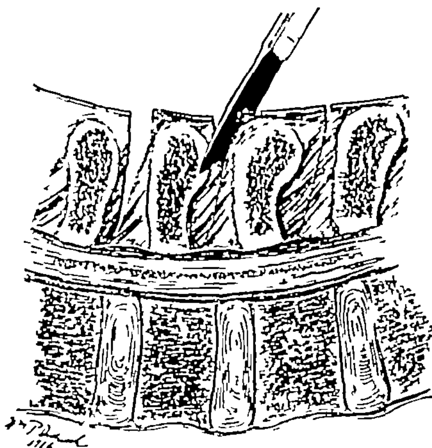


Fig. 47 Laminectomy The division of the interspinous ligaments. (Elsberg.)

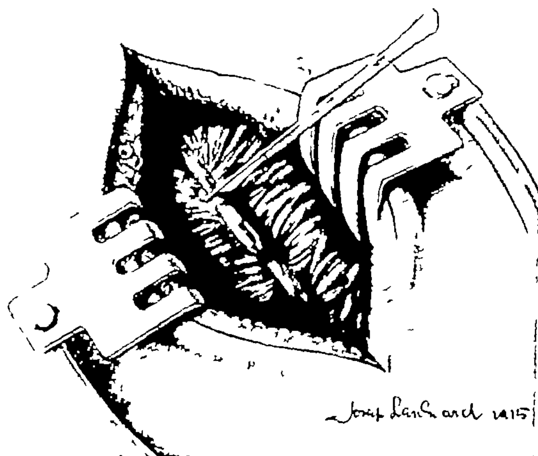


Fig. 48. Laminectomy II The division of the interspinous ligaments. (Elsberg.)

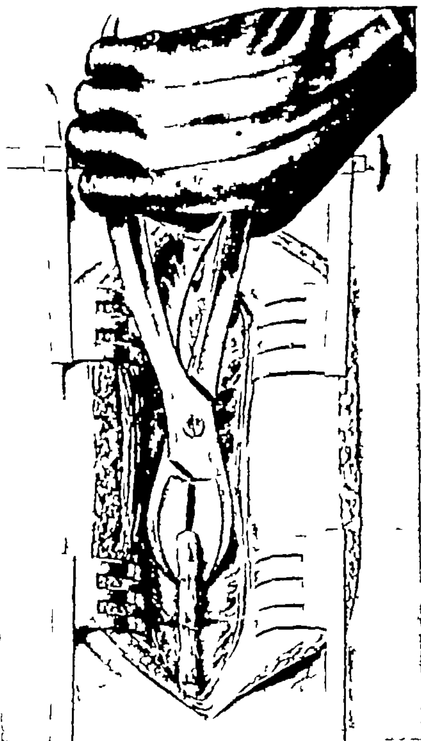


Fig. 49 Technic of laminectomy Removal of the spinous processes. (Frazier)

operation—hemilaminectomy for decompression of the spinal cord and an inlay bone graft for stability and treatment of the Pott's disease.

Technic Alfred S Taylor of New York claims originality and priority in the performance of unilateral laminectomy, which he first performed in 1908 and which consists of the removal of portions of the

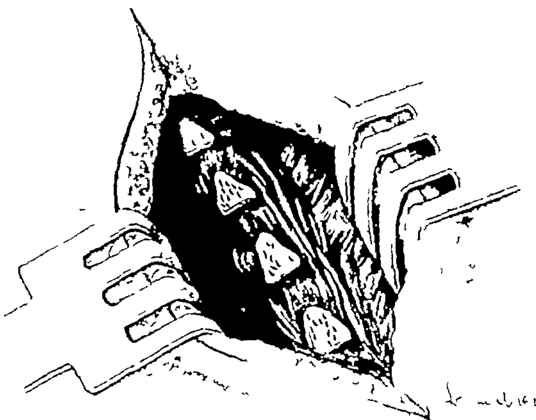


Fig. 50. Laminectomy III. The removal of the spinous processes. (Elsberg.)

laminae of one or more vertebrae on one side of the spinous processes only The use of the senior author's electrically-driven laminatome has greatly simplified the performance of this operation in selected cases

The site of the proposed laminectomy is exposed by a long curved incision, such as is described in the Albee operation for Pott's disease This should extend down to the supraspinous ligament and tips of the spinous processes By blunt dissection and the use of a periosteal elevator the muscles are separated from the lateral aspects of the spinous

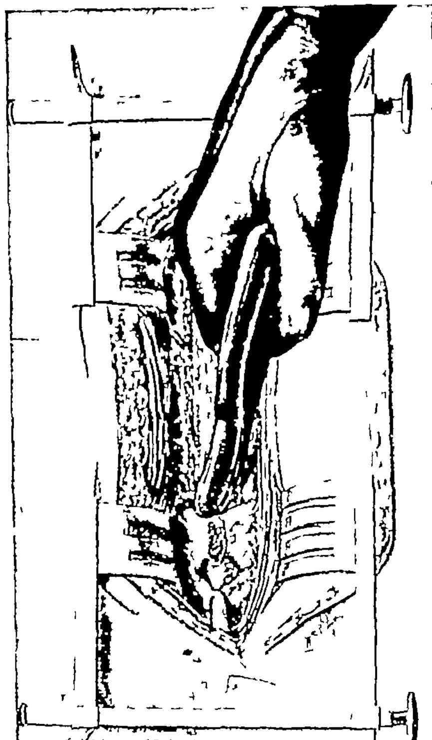


Fig. 51 Technic of laminectomy Removal of the laminae. (Frazier)

processes and the dorsal surfaces of the laminae and retracted outward Hemorrhage should be thoroughly controlled—this can be greatly facilitated by the use of hot saline compresses. The neural arch is pierced by means of a spinal rongeur to make a hole of sufficient size to admit the

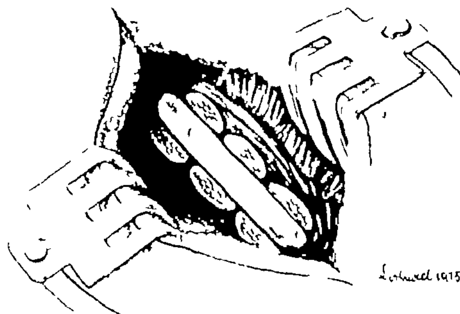


Fig. 52. Laminectomy IV The dura exposed. (Elsberg)

electrically-driven laminatome with which a path is cut through the desired number of laminae above and below the original hole The authors find that by this method, the spinal canal can be entered quickly and safely within a very short time and with a minimum amount of hemorrhage The surgeon may however choose to use the spinal rongeur for the whole laminectomy

If a bone graft is necessary at this time the spinous processes are then split on the side opposite the exposure and the graft is inserted as in Pott s disease This however, may be done at a later date if the condition of the patient precludes additional surgery at this time.

After completion of this operation, the superimposed soft tissues are carefully reunited as described in the technic for bilateral laminectomy and postoperative management is the same



Fig. 53. Laminectomy VIII The suture of the muscles and fascia. (Elsberg)

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CHAPTER V

Fractures and Fracture-Dislocations of the Spine

About 2500 B.C. when a person suffering injury to his spine was *found to be "unconscious of his two arms, his two legs and speechless,"* he was considered to be suffering from an ailment which could not be treated. Later Hippocrates recognized such a condition as not entirely hopeless and began the first systematic treatment by recumbency and traction. However, the treatment of fractures of the spine has progressed very slowly, and it was not until the controversy between Sir Ashley Cooper and Sir Charles Bell as to the value of laminectomy that the profession became stimulated to develop rational therapy. Walton in 1889 described his method of "retrolateral flexion maneuver with rotation," *and this method has formed the basis of our present treatment of* fractures of the cervical spine.*

The experience gained in treating fractures of the spine during World War I and in World War II and the appalling increase in the number of accidents caused by our modern way of life, has given great impetus to the treatment of these fractures. X rays have been of invaluable aid in the early recognition of the problems involved. Immediate skillful treatment is demanded in those cases in which there is evidence of encroachment upon the spinal cord and nerves. Despite the rapid increase in the *incidence of spinal injuries in recent years prompt recognition* of the problems involved, and early treatment, has decreased the number of fatalities.

Mechanisms and Causes. Fractures and fracture-dislocations of the spine are due to direct or indirect violence, or a combination of the two. A direct blow over the vertebrae may cause a fracture of the laminae, spinous processes, or any portion of the posterior arches, but such injuries are not common, and their treatment is quite simple. By far the

* Cole, J. Arch. Surg. 35 528

greatest number of fractures of the spine are compression fractures of the bodies of the vertebrae, and in most cases, one or more of the posterior bony processes are usually fractured, although this is not always demonstrable by x rays In most instances, 85 per cent according to Rogers the intervertebral disc is ruptured and never again functions as a hydraulic cushion between the affected vertebrae * Injury to the spine by indirect violence is much commoner than by direct force This indi

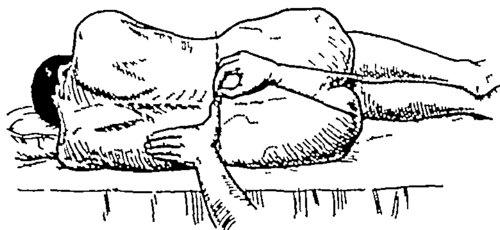


Fig. 54 Position for Spinal Puncture. *(From N O Bourque Diagnosis & Treatment of Head and Spine Injuries Lakeside Clinic and Post-Graduate Hospital Chicago)*

rect violence may be transmitted through skull, sacrum pelvis or os calcis Compression fractures of the bodies of the vertebrae are usually caused by forcible flexion or hyperextension such as falling from a height and landing on the buttocks the feet, or directly on the back

In the cervical spine, the vertebral bodies and articular processes are almost horizontal This predisposes this area to dislocation, more so than the thoracic and lumbar regions where the articular processes are more vertical The commonest causes of fracture and dislocation of the cervical spine are force applied to the head with the neck in acute flexion, hyper extension, or a sudden severe twist.

Fractures of the lower dorsal and upper lumbar spine are very numerous and are most often due to indirect violence The combination of a forward dorsal curve and a backward lumbar curve in addition to the meeting of the almost immovable thoracic spine with the freely movable

* Rogers, Wm A Am J Surg., 599 37

lumbar spine, undoubtedly accounts, to a great extent for the large incidence of fractures in this region.

Fractures of the pedicles laminae and articular facets are usually due to torsion plus hyperflexion or extension, with sudden ligamentary pull Fractures of the transverse processes usually result from muscular contraction or direct or indirect violence and are almost always confined to the lumbar region.

The result of indirect violence upon the vertebrae is dependent on two groups of variable factors 1 The architecture of the vertebrae, the supporting structures and their mobility 2 The type of force, its direction, duration and point of impact In dealing with fractures of the vertebral bodies the fact that the bodies are weight bearing structures must be kept constantly in mind. If the deformity is permanent, the line of weight-bearing is altered, and the normal spinal curves may be radically changed Failure to correct the deformity subjects the muscles and ligaments to undue exertion, and causes strain which is often very disabling

Each vertebra consists of two parts which are quite different in structure and react differently to violence The anterior portion of the vertebra, or body, is made up of relatively soft cancellous tissue but the posterior portion, the neural arch and articulating processes is much more compact—firm bone Although the anterior portion of the vertebrae must bear the brunt of the force the posterior portion is much the stronger and more resistant Therefore the architecture of the vertebrae determines to a great extent the effect of a blow, and this accounts in some measure for the frequency of compression or wedging of the vertebral bodies However this fact is not entirely responsible for the greater susceptibility of the vertebral body to injury because the commonest point of impact is in front of the center of gravity and the mobile cervical and lumbar curves are the regions of least resistance

Extension fractures are rare but extension is usually the mechanism responsible for fracture dislocation of the odontoid process of the axis, and also for comminuted fractures in the lumbar region in which the anterior ends are separated When a blow is applied anterior to the vertebral axis as on the forehead or face extension of the cervical

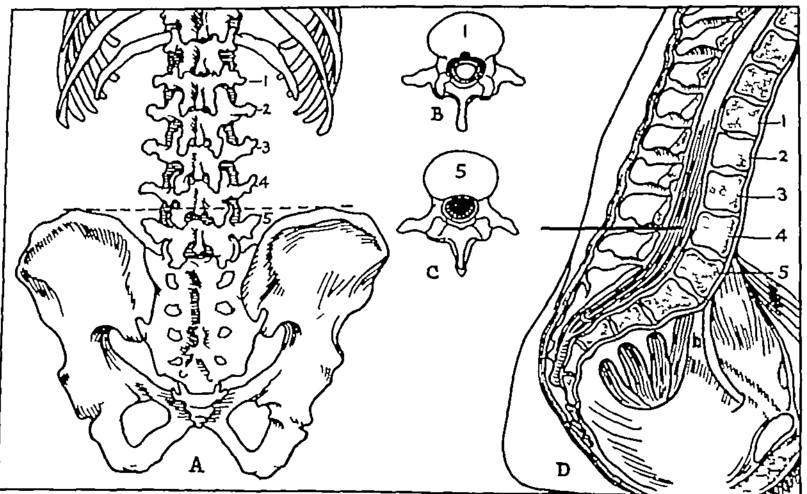


Fig. 55 A A. P View—Intra Crestic Line B—1st Lumbar C—5th Lumbar; D—Lateral View with Position of Spinal Needle. *From N O Bourque Diagnosis and Treatment of Head and Spine Injuries Lakeside Clinic and Post Graduate Hospital Chicago.)*

region may result When the force is applied to the shoulders or pelvis, extension in the lumbar spine is the result.

The causative agents in the production of fractures of the spine are very numerous and varied Therefore, it is important that the spine be examined carefully for injury whenever there is a history of trauma Changes in structure of the vertebrae and the entire trunk may go on in the column for years Some changes are found in all cases but they

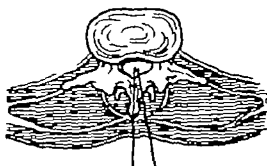


Fig. 56. Directions in which Spinal Needle may be Introduced.

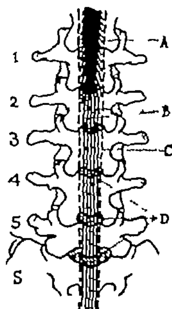


Fig. 57 End of Conus Medullaris and Cauda Equina.

(From N O Bonrque Diagnosis and Treatment of Head and Spine Injuries Lakeside Clinic and Post-Graduate Hospital Chicago)

are maximum when treatment has been inadequate Whenever injury is suspected x rays of the entire spine should be taken in two planes. Many surgeons recommend the oblique plane in an effort to detect fractures of the processes Great care should be taken to show the first and second cervical vertebrae and the seventh cervical, because these vertebrae are often not well visualized in the ordinary x ray examination, and damage to these vertebrae are most often overlooked

Incidence of Fractured Vertebrae Approximately six per cent of all skeletal fractures are fractures of the spinal column, and about one in ten is accompanied by spinal cord injury Compression or wedging of the vertebral body is by far the most common injury occurring in about 90 per cent of the cases reported

The levels at which fracture dislocations most often occur are the most mobile portions of the spine namely, the first and second cervical the fourth, fifth sixth and seventh cervical the eleventh and twelfth dorsal, and the first, second, and third lumbar In the cervical spine the fifth and sixth vertebrae are the ones most commonly injured and in the dorsolumbar regions the twelfth thoracic and first lumbar Approximately 50 per cent of the dorsolumbar fracture-dislocations occur at the first lumbar and 25 per cent include the eleventh and twelfth thoracic as well as the second lumbar

First Aid The treatment of fracture and fracture-dislocations of the spine must begin where the injury occurs The correct handling of a person with injury to the spine, or with suspected injury often has a direct bearing upon the ultimate result—the extent of damage, especially to the cord the prevention of hopeless crippling and often the actual saving of life In no other fracture of the skeletal system is proper first aid so important The time honored dictum *"Splint them where they lie"* deserves its most literal translation in such cases

Recently much has been done in an effort to educate the laity as to proper handling and first aid It is not necessary to make a definite diagnosis of a fractured spine at the site of accident The history of an automobile accident, a fall upon the buttocks or feet from a considerable height, or any direct or indirect force should make one consider spinal injury Trivial injuries such as a slight twist or sprain should be considered as possible spine injuries and proper handling from the site of accident is essential

The foremost cause of fractures of the spine is forcible flexion of the spine upon itself or jack knifing regardless of the force applied, and therefore the original handling must not compound the injury by for instance throwing the person into the back seat of a car or insisting that he make an effort to stand

In transporting a patient with suspected cervical injury great care should be taken to place him in a supine position with slight hyperextension of the cervical spine and slight traction This may be done by the hands alone or by a simple sling of canvas passed under the chin and occiput This position must be maintained until after a definite diagnosis of the injury has been made with x rays

A patient with a suspected fracture of the thoracic, lumbar sacral, or coccygeal regions should always be transported in the prone, hyper extended position He may be put on a stretcher with a folded blanket under his chest to increase the hyperextension, or, if a stretcher is not available, he may be placed on a blanket, care being taken to place him in the prone position The blanket should then be lifted by its four corners, thus producing the necessary hyperextension Shock should be combatted by keeping the patient warm with blankets and hot water bottles X rays taken without removal of clothing, and in the hyper extended position are desirable



Fig. 58. Dangerous method of transport. The spine is forced into flexion and if there is a fracture or fracture-dislocation the displacement must be increased. *(From Watson-Jones Fractures and other Bone and Joint Injuries Williams & Wilkins Co Baltimore)*

It is fortunate that fractures and fracture-dislocations of the cervical spine are not first in frequency But the slightest suspicion of injury to this region demands transportation from the site of accident prompt diagnosis of the problems involved, and adequate treatment—as the most vital part of the spinal cord both from the standpoint of life and function is either being affected or seriously threatened.

Recently there has been a revival of interest among members of the profession in the treatment of these fractures This is probably due to the realization that adequate reduction of the displacement is often followed by complete recovery or marked reduction in the amount of permanent disability

In no other fracture is proper handling, from the scene of accident to the time of reduction and immobilization more important The recent

education of the laity, especially the ones such as ambulance drivers and State police who are most likely to handle such patients during transportation to a recognized hospital, has fortunately begun to show results But in a large measure injured persons are still subjected to transportation methods which although it is impossible to prove in many instances are in all probability responsible for loss of life or permanent paralysis

Because fracture-dislocations of the cervical spine are almost invariably the result of indirect violence they are often associated with cerebral trauma This adds to the difficulty of transportation as a conscious person because of pain will supervise his handling in such a way that the injured parts are held practically immobile It also increases the danger of further spinal cord injury

On admission to the hospital the patient should receive a thorough examination to determine the general condition and to rule out the possibility of fractures elsewhere including the spine as spinal fractures may be multiple The possibility of spinal cord or spinal nerve injury should be carefully determined before x ray examination is attempted If there is definite suspicion of fracture or evidence of cord injury the taking of x rays should be carefully supervised and the technician warned of the dangers of undue manipulation The pain and muscle spasm accompanying cervical injuries is a protective reaction and any attempt to move the head away from this fixed position should be carefully avoided until after a definite determination of the extent of the injuries It is often advisable to proceed with the x rays on a stretcher or a bed moving the tube to the desired angle In an effort to save time the general examination may be carried on during the development of the films

Treatment of Fractures of the Cervical Spine Without Cord Involvement

When examination reveals there is no clinical evidence of injury to the spinal nerves or cord the first consideration in treatment is the prevention of damage by proper handling and treatment However if there is evidence of injury to the cord or spinal nerve roots utmost care is necessary to prevent further damage Prompt reduction of these frac

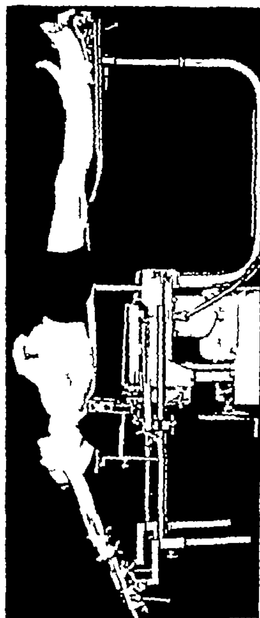


Fig 59 Hyperextension of the cervical spine with traction, by means of the Albee-Comper Fracture Table Traction is available in any plane and in any direction, and skull-tongs may be used in place of the head-halter illustrated. (*The Albee-Comper Fracture Table (booklet) Comper Mfg Company Pittsfield Mass*)

tures is essential, as Brookes has aptly stated Accurate and absolute immobilization is the cardinal principle of early care *

Treatment in these cases must begin at the first examination, but it is impossible to set forth a definite routine of treatment that will apply to every case, as the problems involved vary so greatly in each case The type of treatment must also vary according to the equipment available and the experience of the operator However, the treatment selected should be one least likely to cause damage to the cord or spinal nerves

During recent years with the introduction of improved methods of reduction the treatment of cervical spine fracture-dislocations has departed rapidly from conservatism but variations of the Walton manipulative method for unilateral dislocations and the Taylor method for bilateral dislocations, continue to be used in many hospitals

Skeletal Traction Recently several methods of skeletal traction have been devised which are not only comfortable, but permit the accurate controlling of the strong traction so often necessary By these methods it is possible to reduce many fracture-dislocations which were formerly impossible to reduce by straight traction alone, because of the increased amount of traction which can be safely applied The old Glissen sling method is not only extremely uncomfortable and its traction difficult to maintain in certain instances, as the adjustments are within easy access of the patient but because the sling derives its pull from the chin and occiput, it quite often may be responsible for permanent disfiguration by dislocation backward of the lower jaw

The reduction of a complete unilateral or bilateral interarticular dislocation by simple extension is difficult to accomplish Manipulative methods quite often fail and are extremely dangerous unless in very competent experienced hands

The authors are of the opinion that skeletal traction is the method of choice Strong traction consisting of approximately 10 to 15 pounds should be applied to fracture-dislocations of the upper spine above the fifth cervical, and 20 to 30 pounds for those below the fourth This amount of traction is usually sufficient to accomplish reduction within a few minutes to several hours As soon as reduction is satisfactory the

* Brooke, Dislocation of Cervical Spine (report of 50 cases) Jour Missouri Med Assoc., 1930, 27 579

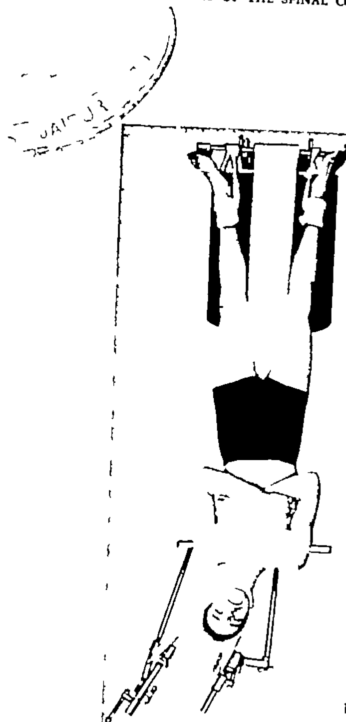


Fig. 60. Hyperextension of the cervical spine with lateral bending, by means of the Albee-Comper Fracture Table. Lateral bending of the head, with traction is obtained by swinging the traction-bars sideways—a most important advantage. (*The Albee-Comper Fracture Table (booklet) Comper Mfg Co., Pittsfield Mass.*)

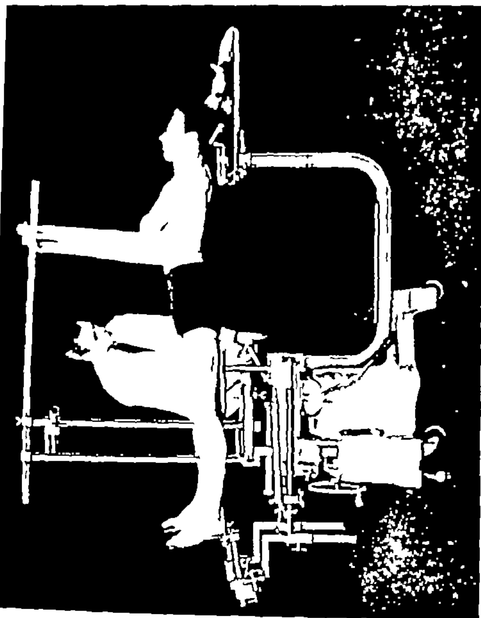


Fig. 61 Crank-controlled hyperextension of the spinal column by means of the Albee-Comper Fracture Table. A turn of the crank handle raises or lowers the sling suspended from the overhead frame the cross bar on the overhead frame is sufficiently wide to splay the sling without the use of a spreader (*The Albee-Comper Fracture Table (booklet) Comper Mfg Company Pittsfield Mass*)

weight is reduced to from six to ten pounds and in some cases a plaster of paris cast is applied immediately If for any reason it is considered advisable to continue traction the minimal amount of traction to maintain reduction is used to prevent damage to the soft tissues

Rarely do we find it necessary to resort to open reduction in cases

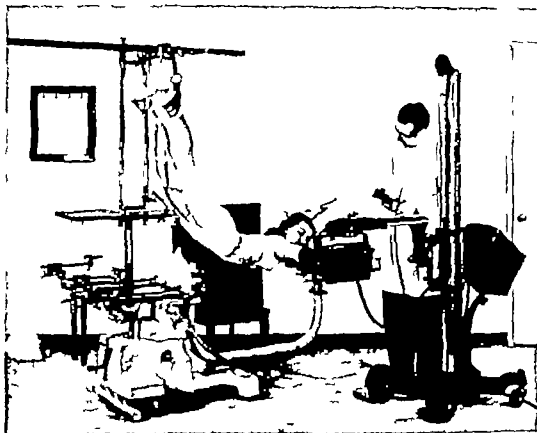


Fig. 62. An x-ray check during hyperextension by means of the Albee-Comper Fracture Table. (*X ray apparatus by courtesy of the Westinghouse X ray Company Inc., Long Island City N Y The Albee-Comper Fracture Table (booklet) Comper Mfg Co., Pittsfield Mass*)

without cord damage Bone graft fusion of the vertebrae involved is the most satisfactory method of preventing further complications

Crutchfield Technic Crutchfield was the first to use skeletal traction, in 1933 for complete forward dislocation of the second cervical vertebrae The results were satisfactory and he was stimulated to continue its use and devise special traction tongs and drill points He does not recommend its use in cases of extremely thin or diseased skulls, or where the scalp is infected He regards skeletal traction as the most

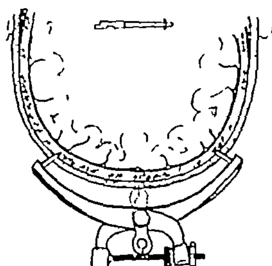


Fig. 63. Correct position of the points of the tongs. When applied in this manner and tightened daily especially during the first few days the tongs will not pull out. The skull should not be drilled blindly except when using a drill point with a fixed guard. *(Journal of Bone and Joint Surgery)*

Fig. 64. The traction apparatus is of simple construction and does not hinder the routine care of the patient.

Fig. 65 The patient may be turned to either side while traction is in force. Change of position not only adds to the patient's comfort, but is extremely necessary for the prevention of pressure sores, especially when the spinal cord is severely injured.

(The Journal of Bone and Joint Surgery W G Crutchfield)



Fig. 66. Fracture dislocation of the fourth and fifth cervical vertebrae (Elsberg.)

satisfactory method of dealing with the majority of fracture-dislocations of the upper cervical spine but feels that laminectomy or manual reduction may sometimes be necessary

Fractures below the fifth cervical vertebra are very hard to reduce by traction alone, and Crutchfield in his early publications states that counter pressure may be necessary against the spines of the posteriorly displaced vertebrae, after traction has produced the unlocking of the intervertebral articulations However his recent experience has proven that these fracture-dislocations are often reducible by skeletal traction when sufficient force is applied and he advocates the use of a maximum of 25 pounds of weight to be applied to the middle and lower regions He prefers the minimum amount of force to accomplish reduction because of the danger of injury to soft tissue

Crutchfield states it is possible to relieve many cases of intractable pain without open reduction or intradural section of central nerve root by the use of skeletal traction

Method of Application The tongs are applied transversely to the vertex of the skull in a vertical plane The mastoid tips are approximately within this plane and serve as satisfactory landmarks

The tongs are designed so the traction bar can be used as a guide for correct placement of the tong points. The traction bar is turned down and placed against the scalp with the arrow pointing to the midline of the skull. The tong points are then lowered to the scalp and the points of contact are marked with a dye to indicate the level of the proposed stab wounds

The scalp is injected with novacain and stab wounds large enough to admit the tong points are made down to the skull Perforations of the outer table of the skull are prepared by using a small drill point about two millimeters in diameter and forcing it to a depth of approximately three millimeters A special drill point with a fixed guard three millimeters from the point has been employed to prevent excessive penetration After the openings have been prepared the tong points are fitted into the bony perforations and made secure by adjusting the thumb screws Dressings are applied and should be changed frequently

The head of the bed is then elevated about twelve inches, and the traction applied The amount of traction to be used depends on the

individual case, and the experience of the operator In high dislocations ten pounds of weight are generally used in low, from 20 to 25 pounds. Traction is left in force for from a few hours to a few days depending upon the rapidity with which reduction occurs When reduction has been accomplished, the weight is decreased from four to six pounds and after reduction has been maintained for some time, a plaster cast is

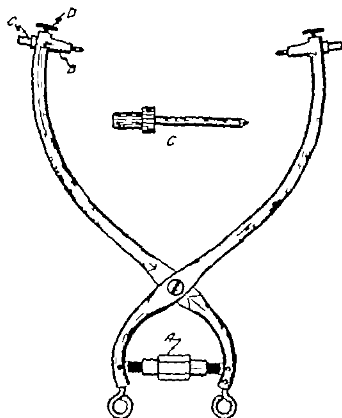


Fig. 67 Barton tongs. *A*, Turnbuckle B, sleeve C drill C_1 drill enlarged D set screw (*From Surg Gynec & Obs Vol 67 1938*)

applied Those patients with little or no cord injury are immobilized in plaster as soon as circumstances will permit and those with complete transverse cord lesions are kept in light traction until at least they have passed the ten-day critical period

Barton Technic Barton who feels that skeletal traction for fracture dislocation of the cervical vertebrae has been demonstrated to be a method of practical value, has devised special tongs for this purpose He applies the tongs at the point of greatest convexity of the parietal bone—a point he estimates to be approximately one inch above the pinna of the ear He selects this point because a greater amount of force

can be applied here without the danger of evulsion of a fragment of bone from the external table of the skull He feels, that with the Crutchfield tongs, the amount of force should necessarily be limited because of the acute angle at which the prongs penetrate the bone The use of

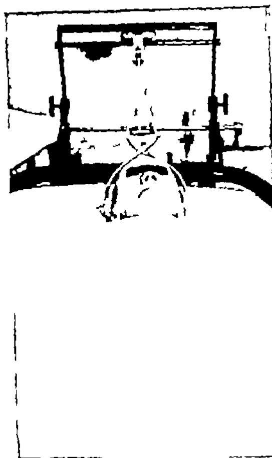


Fig. 68—End view of Barton frame showing mechanism for raising in vertical plane.

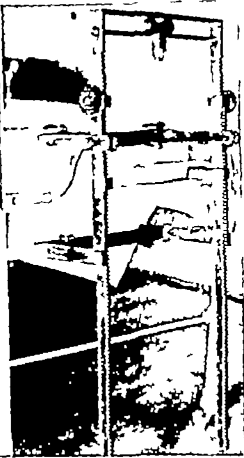


Fig. 69 Side view of frame showing mechanism for raising in vertical plane.

(From Surg Gynec & Obs., Vol 67, 1938)

wires passing through twin holes in the skull is not recommended because of the danger of detaching the bridge of bone to which they are attached

Method of Application A stab wound is made through the scalp to the bone on each side of the head at the points selected the sleeves are inserted into the wound and the tongs closed by means of the turnbuckle until the sleeves are firmly in contact with the bone. The drills are inserted in the sleeves and drilled in until the shoulder on the oute

end of the drill is in contact with the sleeve The drills are left in place and secured from slipping by means of set screws and the traction applied by a special frame attached to the head of the bed This frame has a transverse bar carrying a trolley through the lower pulley of which is passed a cord leading from the wires to the weight for traction To

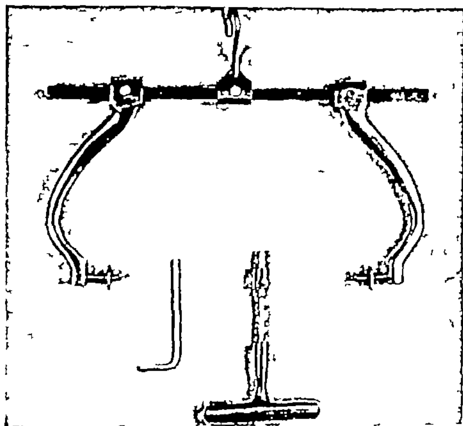


Fig. 70 Skull calipers for skeletal traction of the cervical spine with locking key and small trephine. *(From Watson Jones Fractures and Other Bone and Joint Injuries Williams & Wilkins Co., Baltimore)*

alter the line of traction and to facilitate reduction, the transverse bar with its trolley may be raised or lowered by a threaded shaft The lateral movement of the trolley on the transverse bar enables the patient to move from side to side and to be turned on his side for nursing care without interfering with the traction

Manipulative Methods In the cervical spine, fractures and dislocations may be independent or associated In either case the dislocations may be unilateral or bilateral For the unilateral type, the Walton method of manipulative reduction is extensively used Voris, McKenzie John-

son and others have developed a similar technic, which consists essentially of administrating a general anesthetic and increasing the deformity by rotation of the chin further in the direction already assumed, and slowly flexing the head laterally and posteriorly so as to cause a slight hyperextension toward the side of dislocation

For bilateral dislocations the Taylor manipulative method of reduction remains a method of choice in many hospitals In this a general anesthetic is given, and a head halter, similar to a Glissen sling is applied Slowly hyperextension is produced and when the articular facets are thought to be dislodged with reduction, a cast is applied immediately This is worn for approximately three or four months and then is followed by a Thomas or Dell collar

Immobilization Most authorities agree that the most satisfactory method of primary immobilization of fracture-dislocations of the cervical spine, is a plaster of paris cast, carefully applied However, this method is not always feasible, when there is extensive spinal cord damage and traction must be continued for a considerable period to allow for proper nursing care.

For fractures and dislocations of the upper cervical spine a cast should extend over the head and down to include the iliac crests Fractures below the fifth cervical may be immobilized by casts which are carefully molded around the chin and occiput, and extend over the iliac crests The cast should be made of sufficient strength to permit a window to be cut over the abdomen.

The immobilization in plaster should be continued for approximately three months and followed by a Thomas collar for a variable period of time, depending upon the case and the x ray findings It should be remembered that it is advisable to remove all support as soon as possible, both because of the damage to soft tissue and the mental effect upon the patient When removal of all support is considered advisable the support should be removed gradually and physical therapy carefully administered

Although plaster remains the most satisfactory method of immobilization after reduction, recurrence of the deformity may develop soon after its removal or may gradually increase. The deformity may recur or increase even while the support is being worn

Many fractures and dislocations of the cervical spine are very easily reduced Often they reduce spontaneously The greater the ease of reduction the more easily the deformity recurs and for this reason the authors recommend spinal fusion by inlay tibial bone graft into the spinal processes as a primary treatment immediately following reduction in many cases The authors feel that practically all multiple fracture dislocations should be fused—as well as every one which tends to recur Fusion is often necessary in those late cases which complain of muscle *spasm and intractable pain*

Fusion is indicated

1 When more than one of the bony structures are severely injured

2 In multiple fractures—as a rule.

3 In fracture of the odontoid even though there is no demonstrable vertebral injury

4 When deformities recur following reductions in spite of careful immobilization.

5 For high cervical lesions with paralysis of neck muscles due to cell involvement of the anterior horn of the spinal cord.

Fracture Dislocations of the Cervical Spine With Cord Involvement

Fracture of the cervical spine with evidence of cord involvement presents the most difficult problem of all fracture-dislocations of the vertebrae When the area involved is in the upper cervical, the mortality continues to be about 80 per cent, and many do not even reach a hospital for treatment. The mortality in the cases of complete transverse lesion of the cord is almost in direct proportion to the height of the segment of the cord injured Thus, in injuries of the cervical region above the fourth vertebra death in many instances is almost instantaneous This may be due to injuries of the vital centers in the medulla but is chiefly due to injury of the phrenic nerve.

Although the mortality is very high, many cases with cervical spine injury do reach the hospital for treatment The treatment of patients with complete transverse cord lesions is very unsatisfactory and discour

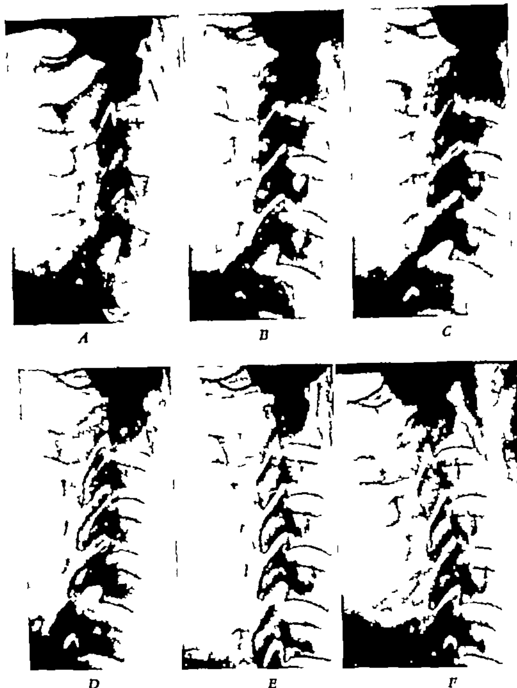


Fig. 71 Fracture-dislocation of the fifth cervical vertebra on the sixth, showing the initial deformity and the various stages of reduction. *A* Deformity on admission. The articular facets are locked. *B* After ten minutes of traction. *C* After twenty minutes of traction. *D* After thirty minutes of traction. The articular facets have separated and the deformity is less. *E* The deformity is corrected. The articular facets have unlocked. *F* The Gatch bed has been elevated and the traction lowered, and the weights have been reduced from twenty-five to eight pounds, allowing hyperextension of the neck and engagement of the articular facets in their normal position. Before reduction, there was a complete manometric block. Immediately after reduction, the test was repeated and the block was found to have been completely relieved.

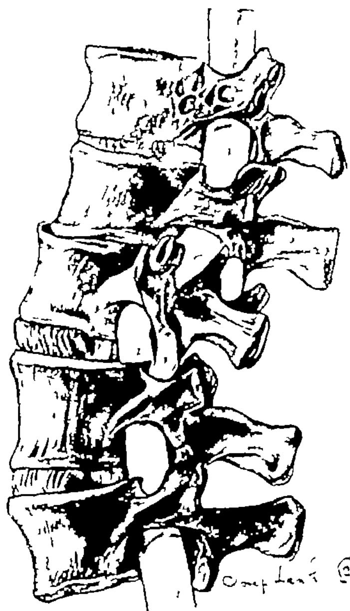


Fig. 72 Fracture-dislocation between the fourth and fifth cervical vertebrae showing angulation of the cord. (Elsberg.) *(From Orthopaedic and Reconstruction Surgery by D H Albee W B. Saunders Co., Philadelphia and New York 1921)*

aging, but everything possible should be done promptly, in an effort to relieve the compression and to prolong life The generally accepted theory that the cord is instantaneously destroyed or ruined, is true in most cases, but a complete transverse lesion of the cord cannot be diagnosed at once either by x rays or neurologically

When it is suspected that the patient has suffered damage to the spinal cord it is very important that neurological examination be repeated at frequent intervals If anything is to be accomplished by treatment, early recognition of progressive loss of function is imperative

A complete transverse lesion of the cord may be deduced from an early persistence of complete loss of all cord function below the level of injury The findings are flaccid paralysis loss of sensation in its various forms particularly sharply defined anesthesia, loss of both deep and superficial reflexes especially the knee jerk, retention of urine often priapism incontinence of feces vasomotor paralysis, with severe swelling of the paralyzed parts tympanites and loss of all sensation

When any evidence of cord function below the level of injury is present, such as demonstration of a Babinski sign preservation of deep sensation, or a deep tendon reflex the damage to the cord should be considered severe, but not a complete transverse lesion In these cases some hope of improvement may be expected.

In these cases it is often difficult to determine whether the complete loss of function was instantaneous because of the accompanying cerebral trauma The intellect is often hazy if not completely lost, and progressive spinal cord involvement is difficult to determine. However the level of damage can be determined clinically to within one or two segments and complete roentgenograms are invaluable

In the conscious and cooperative patient the level may be determined by sensory examination If sensation in any form is retained below the level of damage motor function may return as continuity of the cord is established.

The complete loss of function in fracture dislocations of the cervical spine may be due to bony pressure laceration hemorrhage or edema The edema or hemorrhage may have gradually developed before the first examination, and since it is impossible to definitely state the cause

of the compression, the authors advocate decompression of the cord by laminectomy or hemilaminectomy

Treatment In all cases of suspected cord involvement, every effort must be made to prevent further damage The authors feel that the immediate application of skeletal traction is essential Reduction of the dislocation often decompresses the spinal cord and relieves a certain amount of edema by reopening the spinal canal When reduction is satisfactory a more favorable condition for return of function exists, and nerve root pain is also often relieved. Respiratory and cardiac stimulants are often necessary and artificial respiration either manual or in a respirator if available, may make the difference between life and death.

Every effort should be made to determine if the injury is partial or complete. Repeated neurological examinations should be carefully done, and the Queckenstedt test is often of value

Progressive lesions of the cord, and those cases which do not show improvement should be subjected to laminectomy In the cervical region, a hemilaminectomy is usually sufficient for the decompression, and little weakening of the vertebral column is experienced If a complete laminectomy is done a tibial bone graft on either side of the laminectomy gutter is necessary Following the operation, skeletal traction is maintained to facilitate nursing care Plaster casts are not recommended because of the danger of pressure sores

The authors feel that manipulative methods are poorly tolerated in cases with cord injury and increase the danger of further damage Many fracture dislocations are reducible by skeletal traction alone When laminectomy is indicated and properly carried out it is not a shocking procedure

Complications In no other type of case with the probable exception of pneumonia is proper nursing care more important Recovery of cord function is often retarded or prevented by myelitis resulting from absorption of toxins from infected bed sores bladder or kidneys. Death in most cases that do not succumb to the initial shock of the accident is due to ascending pyelonephritis For this reason every effort must be made to prevent the almost inevitable cystitis incidental to catheterization and the lowered resistance of the bladder walls Because of this many surgeons advocate a suprapubic cystotomy with drainage

as it can be done through a small incision with little anesthesia and by doing away with the frequent catheterizations is less likely to produce cystitis. The introduction of a retention catheter will relieve the distention and often answers the purpose very well Tidal drainage is often a useful procedure. The bladder should be irrigated often with saturated boric acid solution This is especially required after each catheterization A suprapubic cystotomy tube should be changed at frequent intervals Urotropin or sulfanilamide medication to keep urine as aseptic as possible should always be carried out Installation of one ounce of freshly prepared ten per cent argyrol once daily is of value

Bed sores are a great annoyance and are likely to take form within the first few hours after injury These can usually be prevented if, at the very first sign of redness pressure at this point is relieved The sheets must be kept taut, free of loose particles and perfectly dry Air mattresses should be used, and the patient must be turned from his back to first one side and then the other at frequent intervals Air rings placed under the sacrum and heels are often of value The heels must not be allowed to come in contact with any support—this may be accomplished by placing a pillow under the calves of the legs When turned on his side, the patient s feet should be suspended by placing a pillow between the knees, and another under the lateral aspect of the dependent leg As a skin conditioner alcohol followed by a dusting powder is to be recommended, but after the skin sloughs, an astringent such as balsam of Peru should be tried. Cod liver oil dressings often stimulate healing The tendency of pressure sores is to increase in size, and they heal with great difficulty because of the trophic disturbances in the affected tissue

With paralysis of the thoracic muscles, breathing is carried on mainly by the action of the diaphragm. Abdominal distention is often very distressing because of the pressure on the diaphragm and should be relieved by daily enemas or the rectal tube. Daily enemas are also very important to relieve any toxicity

Pneumonia, to which these patients are particularly susceptible is another frequent cause of death Every precaution should be taken to prevent its occurrence

Fracture Dislocations of the Atlas and Axis

The usual cause of fracture of the atlas is a fall or blow of considerable force upon the head. The force is transmitted through the skull to the two lateral articular masses of the atlas, causing them to be forcibly separated. The separation places strain upon the anterior and posterior arches and they fracture because of their weakness. However this injury is not necessarily fatal, and approximately 50 per cent are not accompanied by cord involvement.

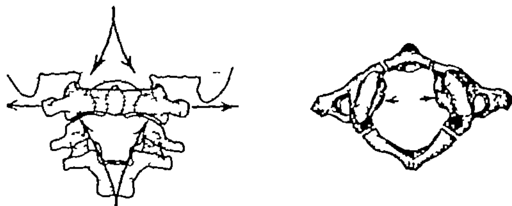


Fig. 73. Fracture of the atlas due to a fall on the head. The force is transmitted through the lateral masses which are driven apart so that the arch fractures at its weakest point. *(After Jefferson Fracture of Atlas Vertebra.) (From Watson-Jones Fractures and Other Bone and Joint Injuries Williams & Wilkins Co., Baltimore.)*

The atlas may be dislocated when the head is forcibly flexed and rotated, but a forward dislocation of the atlas is impossible unless the transverse ligament which secures the odontoid process of the axis to the atlas is ruptured or the odontoid process is fractured at its base. When there is a fracture of the base of the odontoid accompanying the dislocation of the atlas the cord is not commonly compressed because the odontoid being firmly attached to the atlas moves forward with the atlas. However the mortality is very high when the transverse ligament is ruptured without fracture of the odontoid. In such cases the neurocanal is narrowed and the cord is compressed by the odontoid pressing upon the posterior arch of the atlas.

The posterior arch of the atlas is most commonly damaged by either a force applied directly to the skull or forcible hyperextension to the head. Violent hyperextension of the head may cause fracture of the pos-

terior arch of the atlas, or, if force is sufficient, the arch of the axis may also be fractured The resulting posterior displacement of the anterior fragments often causes severe cord compression

Treatment The importance of careful roetgenograms cannot be overemphasized when injury is suspected in this region Fracture-dislocations of the atlas and axis are often overlooked, when they are not

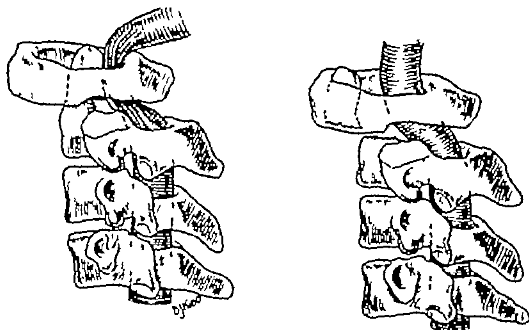


Fig. 74. Forward dislocation (first figure) and fracture-dislocation (second figure) of atlas. If the odontoid is displaced forwards there is less danger of cord compression and survival is common. *(From Watson-Jones Fractures and other Bone and Joint Injuries Williams & Wilkins Co., Baltimore)*

accompanied by compression symptoms and later due to inadequate treatment may produce severe cord damage

As an immediate treatment, the authors recommend skeletal traction for the majority of fractures in this region—and especially for those accompanied by paraplegia

Fractures of the arch of the atlas and those of the odontoid without evidence of cord involvement, may be immobilized in plaster within several days following the injury or when reduction is accomplished The cast should extend over the head and down to include the crest of the ilium The cast should be worn for approximately three months The old opinion that the odontoid unites only by fibrous tissue is not true

if satisfactory reduction is obtained and sufficient immobilization is maintained. Nonunion, however is not rare.

Those cases which present immediate or progressive evidence of cord involvement, and fail to show improvement within several hours after application of skeletal traction should receive immediate hemi



Fig. 75-A. X rays of a successful case operated upon by Dr W E. Gallie of Toronto, Canada *(Illustration personally loaned to the authors)*

laminectomy or laminectomy as the case requires C and Turner find it necessary to remove the pos erior arch o t accomplish decompression of the cord

Reduction of the disloc easily by traction alone within from a few eral ho ence of the deformity frequently d the trac ed

or may increase even while the plaster cast is worn Many cases develop cord involvement several months—and sometimes as much as 20 years—following the initial injury which had affected only the bony struc



Fig. 75-B A diagram demonstrating Gallie s technic. It shows a large graft which has been taken from the crest of the ilium and mortised into the spinous processes of the axis and on to the posterior and inferior surfaces of the central portion of the posterior arch of the atlas and held in place by fine wire.

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This problem has engaged the attention of many surgeons and the majority agree that the answer lies in *spinal fusion* Gallie is convinced that one can foretell from x rays which cases are likely to have a tend

if satisfactory reduction is obtained and sufficient immobilization is maintained Nonunion however, is not rare

Those cases which present immediate or progressive evidence of cord involvement and fail to show improvement within several hours after application of skeletal traction should receive immediate hemi-



Fig 75-A X-rays of a successful case operated upon by Dr W E Gallie of Toronto, Canada (Illustration personally loaned to the authors)

laminectomy or laminectomy as the case requires Cone and Turner find it necessary to remove the posterior arch of the atlas to accomplish decompression of the cord in some cases

Reduction of the dislocation is often easily accomplished by traction alone within from a few minutes to several hours, but recurrence of the deformity frequently develops when the traction is discontinued—

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ency to recur following removal of plaster supports and advises immediate fusion in such cases to save time Cone and Turner have come to the conclusion that all cases of fracture of the odontoid even though there is no other demonstrable vertebral injury, should be fused

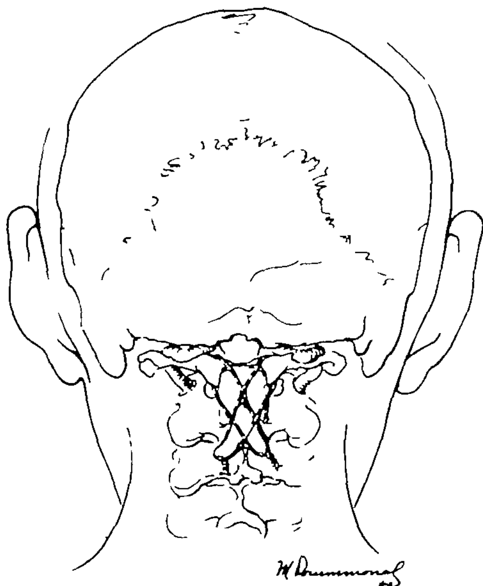


Fig. 75-C. Diagram seen from the rear with graft and wires in place.

Albee Method of Fusion of Upper Cervical Spine The technic of this operation is similar to that described for Pott s disease on page 185 The authors use a solid tibial graft, shaped to fit the curvature of the occiput into which it is carefully inlaid through the outer table The inlay is just posterior to the foramen magnum around the immediate

rim of which the skull tables are amalgamated The graft is so angulated that it fits into and is also inlaid into the split spinous processes, and should include at least two vertebrae below the fracture The soft tissue, including split supraspinous and interspinous ligaments are carefully sutured over the graft in layers, and it is not necessary to anchor the graft with additional sutures, in most cases If it is necessary to anchor the graft to the occiput, kangaroo tendon is introduced through drill holes in the outer table Skeletal traction should be maintained during the operation to prevent recurrence of the dislocation, and fol

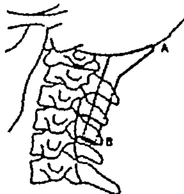


Fig. 76. Albee method of shaping tibial bone-graft for cervico-occipital fusion to prevent dislocation of the atlas. *(Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Co., New York)*

lowing the operation this type of immobilization is very satisfactory The skeletal traction may be discontinued after the first six weeks if a cast is desired.

Fracture of Dorsal and Lumbar Vertebrae With or Without Cord Involvement

Fractures of the body of the dorsal and lumbar vertebrae are due to violent hyperflexion. Injuries to the bodies should always be suspected when there is a history of 1 A blow upon the head 2 A fall from a distance with the patient landing upon the feet, buttocks or head 3 An automobile accident with symptoms of back injury

The three types of vertebral body fractures usually described are simple wedge which is the commonest comminuted fracture the rarest and fracture-dislocation

Simple Wedge Fracture Usually more than one vertebra is involved and there is a reduction in the anterior vertical diameter with forward bulging of the cortex at the upper and lower angles This bulging may be apparent in several vertebrae, or the obvious injury may be confined to only one vertebra, but with actual measurements of the adjacent bodies showing slight diminution Fractures of the accessory processes

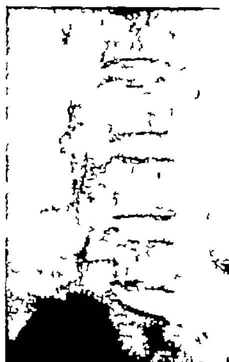


Fig. 77 A. Case 1 Crush fracture involving the posterior wall of the centrum of the fourth lumbar vertebra. Mild wedge-shaped compression fracture of the centrum of the second lumbar vertebra.



Fig. 77 B. Case 1. Post-mortem specimen.

(W A. Rogers Jour Bone and Joint Surg)

are often not demonstrable by x rays and no one interarticular joint dislocation is apparent

Comminuted Fracture The force producing this injury is usually more acute or localized. The anterior angle of one of the vertebral bodies is forced into the middle of the adjacent body by sharp angulation at the intervertebral disc level The intervertebral disc is often ruptured and forced between the fragments Narrowing of the intervertebral disc space is more commonly seen in this type of injury than any other frac

ture of the spine, but rupture of the disc promotes bony ankylosis between the adjacent vertebrae and persistent pain following incomplete reduction is not uncommon

Fracture-Dislocation When the forceful hyperflexion is not spent when the body fractures, dislocation of the vertebrae occurs This injury is primarily an intervertebral dislocation, and is possible only after the tearing of the ligaments about the vertebral body The anterior longitudinal ligament which often remains intact in fractures, is probably always torn to some degree in dislocation and with the trauma to the neural arch the upper segment of the spine slips forward The damage to the neural arch may be a bilateral dislocation at the interarticular joints fracture of the pedicles or laminae, or a combination fracture and dislocation of the accessory processes Cord injury in this type of trauma is frequent, and is due either to narrowing of the lumen of the neural canal by bony displacement, or hemorrhage or edema of the cord

Treatment of all cases of suspected fracture-dislocations of the vertebral bodies must begin at the scene of the accident Correct handling during transportation and immediate, or as soon as feasible, determination of the extent of injury by x rays are essential The modern principle of treatment for most vertebral body fractures is reduction by hyperextension and later fixation in a plaster cast However, all authorities do not agree at what time this should be attempted when there is evidence of severe dislocation. To accomplish a satisfactory reduction, the spine must be hyperextended to its physiological limits, or slightly beyond Reduction depends upon the tension on the anterior longitudinal ligament but in fracture dislocation this ligament is often lacerated partially or completely and the danger of hyperextension producing further damage to the cord is increased as the internal splintage of the external longitudinal ligament is lost to a great extent

Correct reduction of the wedging is extremely important, as changes in structure resulting from fractures may go on for many years producing severe pain Persistent pain may even be severe after the fragments have united in relatively good position and in those cases in which reduction has been inadequate or delayed severe persistent pain is a common complaint

Changes in the spinal column are demonstrable in every case of fracture, but these changes are maximum when reduction and fixation have been inadequate, and minimum when the treatment has been correct. The changes to be expected are 1 Those occurring locally at the site of fracture 2 Those of the entire spinal column as a whole

1 Local Changes (*a*) *Narrowed Intervertebral Disc* There may be a narrowing of the intervertebral disc space above and below the fractured vertebrae, because of the rupture of the nucleus pulposus or the replacement by fibrous tissue of the damaged intervertebral disc and subsequent weight-bearing This may account for a slight kyphosis, but this is not an important source of persistent pain, although there may be slight local pain or tenderness

(*b*) *Spur Formation* The formation of bony spurs at the anterior margins of the vertebral bodies, and increased bone density at the end surfaces does not seem to be a source of extreme pain Most authorities agree that it is not evidence of arthritic changes These proliferations of bone are more commonly found in cases which have been inadequately reduced and immobilized. Spur formation may develop due to subperiosteal ossification in the attachment of the anterior longitudinal ligament, but is not a source of persistent pain When the spurs are large, they are usually the result of unreduced fragments of the fractured body

(*c*) *Nerve Root Pressure* This is a very common cause of persistent pain, and is due is many instances to either the settling together of the vertebrae with a narrowing of the foramen at the intervertebral notches or to excessive callus formation Excessive callus is prone to develop when there has been incomplete reduction or alignment and inadequate immobilization

(*d*) *Calcification of Ligaments* The narrowed intervertebral space may be bridged completely or partially by calcification of the surrounding ligaments This occurs even when alignment is satisfactory and is not a usual source of pain

(*e*) *Prolapse of the Nucleus Pulposus* Trauma of the intervertebral disc may prolapse the nucleus pulposus into the centrum, or a portion may be extruded into the neural canal, giving rise to cord or nerve root

symptoms—but this is uncommon However, when there is a prolapse of the nucleus pulposus the cushion effect between the vertebrae is lost, and the herniation into the centrum is soon surrounded by dense bone.

2. Changes in the Spinal Column as a Whole The changes in the spinal column as a whole from fracture of the spine are of extreme clinical importance When the normal curves of the spine are altered the line of weight bearing is changed, and the normal stress upon the ligaments and muscles is increased producing symptoms which are often very severe. Prevention of the alteration in the normal spinal curves can best be accomplished by complete reduction and careful immobilization

VARIOUS METHODS OF REDUCTION

Many methods of reduction have been devised during recent years for treating the crushed vertebral body They are all based upon the principle of hyperextension and adequate fixation but vary considerably as to technic.

Davis Method This method was first described during 1927 and is now extensively employed by the profession The authors have used this technic successfully on many occasions, and the Albee-Comper Fracture Table has been so devised as to include this method

Davis describes certain features of spinal anatomy which have been utilized as agents in reduction, and interprets them as follows

1 *Strength of the Anterior Longitudinal Ligament* All crush fractures whether cervical thoracic or lumbar, with or without dislocation or neurological signs, depend primarily upon the anterior longitudinal ligament for their reduction (In all Davis cases the anterior longitudinal ligament was regarded as the check to any possibility of overhyperextension Cadaver specimens were studied to determine the strength of the anterior longitudinal ligament and the findings showed that this ligament is almost non-elastic and will withstand an average tension of 337 pounds.)

2. *The Fulcrum of the Posterior Spinal Joints*

3 *The Intervertebral Discs* The firm attachment and relative invulnerability of the intervertebral discs together with the firm incorpora

tion of annulus fibrosus with the anterior common ligament and epiphyseal plates insure restoration of circumference and general contour

4 *The Density and Resistance of the Lateral Masses* The thickness and resistance of the cortex of the accessory processes are sufficient to

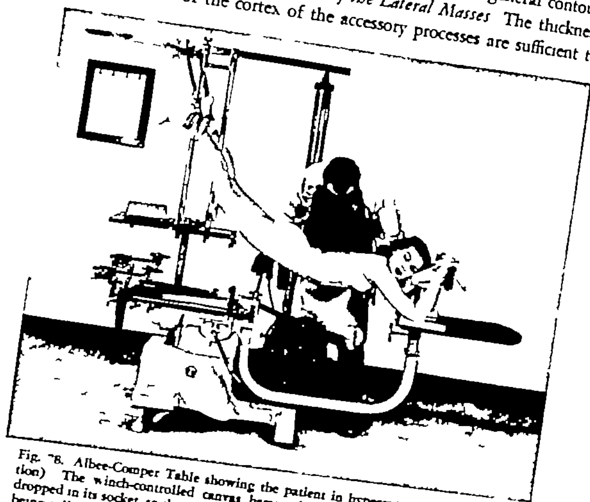


Fig. 78. Albee-Comper Table showing the patient in hyperextension (Davis position) The winch-controlled canvas hammock, but not the overhead frame is dropped in its socket, so that there is nothing in the way to prevent the patient from being rolled over from a wheel-stretcher face downward onto the canvas. The overhead frame is then dropped in place on the crank-controlled crane, the canvas holder attached to it and drawn taut by the winch, and patient lies solidly on the table as shown, while her legs are being suspended. The table-top panel lowers out of the way and, with center panels, may be removed altogether Illustration also shows ease with which fluoroscope and x-ray check-ups can be made during hyperextension. (*The Albee-Comper Fracture Table (booklet) Comper Mfg Co., Pittsfield Mass*)

oppose the fracturing force and are likewise strong enough to withstand the stress of reduction

Davis does not feel that it is necessary to watch the patient for symptoms or signs of impending paralysis or root pressure during suspension and does not consider roetgenograms necessary during suspension No

anesthetic is given, and opiates only in selected cases. Those cases which present prohibitive complications, such as shock, cerebral involvement or multiple fractures, are extended or partially extended on a frame, not hyperextended, or the patient is kept prone, with permission to raise himself on his elbows, until adequate treatment is considered advisable.

Those cases which appear to require laminectomy are first placed in plaster shells with the spine in hyperextension. Davis states that since hyperextension increases all diameters of the intraspinal space, hyperextension is becoming recognized as a better decompressor than laminectomy.

Technic for Fractures of Lumbar and Lower Thoracic Vertebrae

1. First aid treatment. Patient should be rolled into the prone position at the site of the accident.

2. An x ray should be taken as soon as advisable. The Albee-Comper Fracture Table is designed especially to facilitate the taking of all desirable x ray exposures.

3. A neurological examination should be made and if there is nerve involvement careful analysis should follow. (Partial paralysis was relieved in a number of cases cited by Davis.)

4. In cases with no paralytic symptoms fracture should be reduced immediately by the foot suspension method, and a three point pressure jacket, extending from the clavicle to the pelvis, applied. The usual head suspension apparatus is used to completely elevate the lower extremities until the pelvis clears the table by several inches. The suspension is done in an upward and footward direction. The center of suspension is placed about 12 inches distal to the foot, and the knees are flexed to an angle of 45 degrees rather than 90 degrees, thus obtaining horizontal traction as well as hyperextension. Minimum pressure is exerted on the posterior arch of the involved vertebrae. After sufficient suspension has been gained, in those cases in which the knuckle remains prominent, manipulation is made by several quick but measured downward thrusts at the side of the gibbus, in an effort to disengage the impaction, reduce dislocation, or correct alignment.

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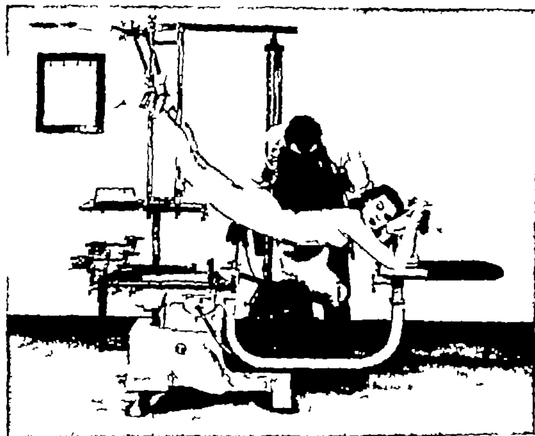


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5 On the next day a check up roentgenogram should be taken If this shows insufficient reduction, remanipulation using thrust if necessary should be instituted

6. Another check up roentgenogram should be taken

7 The patient should be kept recumbent for six weeks free to change position, but not to sit up

8 The jacket should be shortened at this point, or, if there has been loss of weight, the jacket should be changed Results should be checked again with x rays.

9 The patient should be allowed to be ambulatory for six weeks The vibrational influence of walking serves to induce the strengthening of the necessary perpendicular structural trabeculations

10 The jacket should be removed, and careful detailed Bucky x rays taken The patient should be warned against lifting heavy weights in the stooped position and should be given exercises to develop the abdominal muscles.

Dunlop Method In this method the principle of traction and hyper extension is also employed in compressed and impacted fractures The molding of the fragments into position is accomplished by the compression of the surrounding ligaments and muscles when put on tension Dunlop stresses early attempts at reduction, and advises the use of oblique roentgenograms more frequently Perfect restoration of the normal height of the vertebral body is possible, except in those cases where comminution is present the expanding force of the intervertebral disc has injured the upper or lower plate of the body or the anterior spinous ligament has been torn so as to loosen its grasp on the fragment Reduction of the compressed and impacted fractures high in the dorsal region above the seventh or eighth vertebra are very difficult and sometimes impossible to reduce

Technic for Compressed and Impacted Fractures

1 Patient should be placed on an ordinary flat top table and his entire trunk enclosed in a snugly fitting stockinette, inside of which have been placed lengths of muslin bandages to be used later as leaders for gauze scratchers

2 Anesthesia should be given preferably avertin and gas

3 An assistant should balance the legs while another balances each arm

4 The body is then carefully brought into the desired amount of hyperextension Dunlop accomplishes this in three ways, by grasping the body, around and under, with the arm, by using a sling and block



Fig. 79-A. Case 3 Roentgenogram on admission, showing fracture-dislocation of the eleventh and twelfth thoracic vertebrae



Fig. 79-B. Case 3. Correction obtained by traction-extension. The dislocation has not been reduced posterior replacement of the eleventh thoracic vertebra has not occurred.

(W A. Rogers: Jour Bone and Joint Surg)

and tackle (the easiest way) or by passing a folded sheet beneath the body and tying it over the operator s shoulder Very little force is required in the average case, and the operator can easily gauge the amount being applied

5 Following sufficient hyperextension, the patient is placed on the padded Goldthwait frame care being taken to maintain the hyperextension. Previous to the manipulation the irons of the Goldthwait

frame are bent, so as to bring the height of the curve just at the level of fracture The spine is automatically molded into its correct alignment when the patient settles on the frame

6 Lateral x rays should then be made to determine the exact position of the fragments If the correction is not satisfactory the hyperextension is again applied Seldom is it necessary to make more than two or three attempts (The Albee-Comper Fracture Table designed since Dunlop s work is of inestimable value in carrying out all the details of his technic, and is particularly valuable for the taking of x rays in any plane)

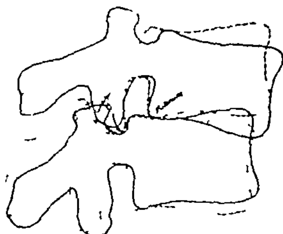


Fig. 80 Diagram showing the effect of extension in fracture-dislocation when the posterior articular processes do not engage normally If the processes do not lock to prevent further extension, cord or root injury may result from the maneuver by encroachment of lamina and processes on the neural canal (W A. Rogers Jour Bone and Joint Surg)

7 When the position is considered satisfactory a plaster jacket is applied with the patient still on the Goldthwait frame The cast should extend from the neck to the pelvis.

8 The cast is trimmed after it has completely set, and the steel bars are removed A window over the epigastrium is considered advisable

9 The patient is kept in bed—not even allowed to turn fully on his side and never on his face. He is kept in this position for from 14 to 16 weeks At the end of this time full activity is allowed or a Taylor brace is worn for a few months.

Technic for Fracture of the Vertebrae with Lateral Displacement When the alignment of the spinal column and the articulations between the adjacent vertebrae are completely destroyed, the problem of care

is very different from when there is a simple compression Paralysis is present, and its degree depends upon the amount of damage done to the cord and spinal nerves Regardless of the degree of paralysis the patient should be given the benefit of every doubt and an attempt should be made to realign the fragments Dunlop advises that they be treated as follows



Fig. 81 One of the methods of producing hyperextension. Th patient is placed on the Goldthwait frame. He is balanced by one assistant who holds the legs, and by two others who balance the shoulders by means of a folded sheet passing to the opposite axilla. A folded sheet is passed under the body at the level of the fracture and is tied over the shoulders of the operator who then lifts the spin into the amount of hyperextension necessary to pull out the impaction of the vertebrae When this is accomplished, the patient is lowered to the bars of the frame and an x ray film is made to note the success of the maneuver and of the moulding of the spine on the frame. If the result is satisfactory the plaster cast is then applied without further moving the patient. *(From American Journal of Surgery)*

1 The Goldthwait frame should be prepared, with special attention to the curves of the bars—or the Albee-Comper Fracture Table as the surgeon prefers may be used.

2 The patient should be lifted very carefully onto the frame or table, and during the process as much traction should be applied on the arms and legs as possible

3 Strong traction on the legs and arms should be continued by as sistance or by the use of folded sheets under the axillae The body is

slowly lifted into hyperextension several times to bring the fragments into alignment.

4 Roentgenograms—anterior, posterior and lateral views—should then be taken If the realignment is not satisfactory, a molding process may be continued several times until sufficient reduction has been effected to relieve pressure.

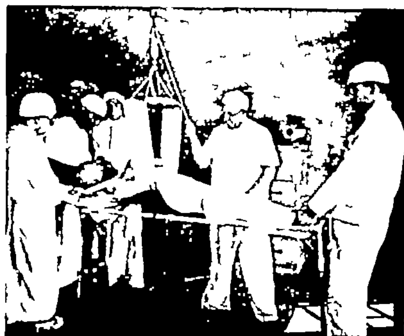


Fig. 82. Another method of producing hyperextension, devised by Dr. John Wright of Pasadena, Calif. It is easier on the operator in controlling the amount of hypertension. In other respects it is exactly the same as the method indicated in Figure 84. *(From American Journal of Surgery.)*

5 A plaster cast is then applied while the patient is still on the frame (or table)—just as in compressed fractures

6 When the cast is set the patient is removed from the frame (or table) The cast should be sufficiently firm before the bars are removed The bars may be left in for a few hours without harm

7 Every case with paralysis should have the advantage of reduction Special care of the paralytic patient is very important The deformity should be reduced as soon as possible, and the cast applied properly and well padded If the paralysis is complete, the cast should be split into anterior and posterior shells Every effort should be made to avoid pressure and the limbs should be kept in neutral position The patient







Fig. 83 *Upper* Correct position for postural reduction. *Middle* Incorrect position. The lower table extends beyond the groins and prevents the pelvis from tilting forward. The lumbar spine is incompletely extended. *Lower* Incorrect position. The patient is too close to the upper table. The thoracic spine is incompletely extended and the jacket cannot be carried high enough. Displacement will recur (*From Journal of Bone and Joint Surgery*)

should be turned frequently, and all skin areas should receive immaculate care Paralytic bladders become infected very easily, and catheterizations must be carefully done The bowels should be cleansed daily by enemas

Watson Jones Postural Reduction Method The unsupported trunk finds its own limit of hyperextension. Reduction depends on the ten-



Fig. 84 Incorrectly applied plaster cast. It is cut too high at the groins and too low over the chest. Displacement of the fracture will recur



Fig. 85 Correctly applied plaster cast extending from the groins and the symphysis pubis to the clavicle The lumbar spine cannot be flexed. *(From Journal of Bone and Joint Surgery)*

sion of the anterior longitudinal ligament. It is not enough that the spine be extended, it must be hyperextended to its normal limit to produce sufficient tension on the anterior longitudinal ligament to complete and maintain reduction Only if this limit is reached and maintained is it impossible for the vertebral body to collapse whether or not the patient is ambulatory

The normal range of extension movement varies in every patient The ligament may be taut at 20 degrees in the short thick type but 60 degrees of hyperextension may be required to reach the limit in another Controlled or fixed degrees of extension by slings or curved

surfaces are imperfect The trunk should be entirely unsupported so that it sags into space to the limit of the patient s extension movement

The patient is placed prone between two tables—the trunk unsupported the pelvis tilted forward, and the spine sagging to its limit of hyperextension A general anesthetic is not advised unless the case is of long standing and then the Davis method of reduction is considered more convenient High thoracic fractures are very difficult to reduce regardless of the technic employed For this fracture the pump-up kidney bar on an operating table is used to produce pressure under the kyphosis

The plaster cast must be carefully applied and should remain on for from four to six months. The cast often becomes loose, and in many cases should be changed with the spine in hyperextension, after from four to eight weeks following the original reduction Often an excellent primary treatment has been wasted, because the jacket has been removed too soon Crushed vertebral body fractures are slow in consolidating and it is unsafe to allow flexion movement in less than four months The comminuted fracture is very slow in uniting and in such cases the jacket should be retained for six months It is a mistake to use a posterior spinal support at any stage of the treatment, as this cannot prevent collapse of an unsoundly consolidated fracture, and gives a false sense of security to both surgeon and patient

Bone Graft Fusion for Fractures of the Spine Without Cord Involvement

Fractures of the upper cervical spine very frequently require fusion to prevent damage or increasing damage to the cord and all fractures of the cervical spine which tend to recur during the wearing of or following the removal of the support should be fused Many authorities agree that all fractures of the odontoid should be fused, even though demonstratable vertebral injury is not present. Patients complaining of latent pain regardless of the region involved should receive the benefit of fusion, as this is the only means of relief

Bone graft fusion is often indicated as primary treatment in selected cases of fractures in the dorsal and lumbar regions without evidence

of cord damage Considerable time and discomfort is often saved, and the possibility of latent pain is greatly decreased by such fusion In cases where the patient must earn his livelihood by hard manual labor the authors believe the advantages of early spinal fusion should be explained, and the decision for or against the operation left to the patient.

To illustrate The senior author was called to see the patient of a young orthopedic surgeon The patient, a polo player who had recently fallen from his horse, was suffering from a severe compression fracture of the dorsal region The young surgeon had recommended spinal fusion as the primary treatment of choice but a consultant, called in on the case did not agree. The senior author, after reviewing the case carefully, recommended to the patient the following two courses of choice 1 Treatment by the conservative method of hyperextension. 2 Immediate spinal fusion If the conservative method were chosen, the senior author pointed out the fact that it would probably require six months of immobilization in plaster before it would be safe to remove the support following the removal a considerable period would have to be devoted to physical therapy to strengthen the atrophied spinal muscles also the patient might develop considerable latent pain which would necessitate a spinal fusion later If immediate spinal fusion were decided upon, he would not necessarily be required to wear any form of support, and within three months he should be able to ride his horse again, and within a few more months play polo again The patient chose immediate spinal fusion with a perfect result.

Several salient factors should be considered in recommending spinal fusion for fracture of the spine

1 Adequate x rays should be taken to determine the exact extent of damage to the column Lateral x rays should always be taken and oblique roentgenograms are often necessary

2 Fusion is not usually advisable in elderly patients as an early recovery is not expected but the danger of pneumonia must be considered during the long immobilization The patient should be told of the possibilities of the operation

3 Younger patients not doing hard labor do not usually require fusion but they should also be told of the operation and allowed to make their own decision

4 The operation may be advisable in many young patients who must continue to earn their livelihood by hard manual labor, as they are returned to their occupation much sooner, and the possibility of latent pain is decreased diminished or rendered negligible

5 The bone graft must be considered a possibility in all cases which have been treated by the usual conservative methods and continue to have pain and symptoms after from three to six months and especially for those cases which have pain, even though they are wearing a brace

6 Bone graft fusion must be considered in all cases of fracture of the upper cervical spine without cord damage, especially in fractures of the odontoid where non union is so apt to occur and those which tend to recur, either during or following the removal of support

7 Spinal fusion is the means of relief for all cases of fractures of the spine which complain of latent pain, regardless of the region involved

Fracture Dislocations of the Lumbar Dorsal Spine With Cord or Cauda Equina Involvement

Reduction of vertebral dislocation may be very difficult and should not be attempted until a complete study of the case has been made, both clinically and roentgenically However valuable time should not be lost before attempts at removal of the cord pressure is undertaken by the procedure of choice

Complete clinical determination of the extent of cord damage is impossible in most instances especially during the early stages Paraplegia, due to loss of conductivity from compression traction or contusion, with the nerve cells or fibers intact may present the same picture as in an injury producing complete loss of continuity Repeated clinical and radiographic examinations will often be of value in the determination of the probabilities of the extent of cord damage but may not give a positive diagnosis

Early examination often reveals a flaccid paralysis with complete loss of both skin and deep sensation, and often an area of hyperesthesia at the actual level of the cord injury There may also be a complete absence of superficial and deep reflexes with incontinence of urine and feces

Examination of the cerebrospinal fluid may be of value, but a negative response to the fluid pressure test after jugular vein compression (Queckenstedt's test) does not exclude the possibility of marked displacement at the time of injury The presence of blood in the fluid may indicate a severe intraspinal injury

Radiographic examination taken in three planes, whenever the condition of the patient permits, may make it possible to determine whether transection of the cord is likely, although the position of the vertebrae at the time of examination in all probability is entirely different from that assumed at the scene of the accident Because of improper handling many cases have suffered irreparable damage to the cord before reaching the hospital Others may be reduced simply by placing them upon a flat table

Fracture-dislocation of the vertebrae is the injury most commonly associated with paraplegia. In the upper thoracic spine, the cord practically fills the neural canal and is held almost stationary by the nerve roots and ligamentum denticulatum Therefore, the slightest forward displacement of the upper segment will compress the cord, producing irreparable damage In the lower half of the dorsal region, the danger of cord damage is slightly less Displacement of the fragments in the lumbar region is possible to a great extent without causing permanent cord damage This is due to the large caliber of the lumen of the canal *and the relative mobility of the nerves of the cauda equina* The nerves of the cauda equina are capable of regeneration and when fractures below the first lumbar are reduced promptly a large percentage may expect recovery

Wedge compression fractures and comminuted fractures of the body do not often produce extensive cord damage. However when they are incompletely reduced, delayed paraplegia and pain from root pressure may develop because of callus formation and increased deformity

Treatment When symptoms of cord damage are present degeneration of the cord may follow so rapidly from pressure or ischemia that treatment must be instituted without delay The cardinal principle of early treatment is removal of cord pressure, but the profession continues to have varying opinions as to how this should be accomplished



Fig. 86. Recurrent interarticular joint subluxation. Three years after injury there is still severe root pain (first figure) After extension of the neck and operative fusion the symptoms were relieved (second figure) *(From Watson-Jones Fractures and Other Bone and Joint Injuries Williams & Wilkins Co Baltimore)*



Fig. 87 Recurrent interarticular joint subluxation after operative fusion with tibial bone graft, showing the range of movement which is possible (same case as Fig. 39) *(From Watson-Jones Fractures and Other Bone and Joint Injuries Williams & Wilkins Co., Baltimore)*

Fracture-dislocation of the bodies of the vertebrae are often complicated by fractures of the accessory processes The articular processes may be locked and any attempt at hyperextension will necessarily increase the damage to the cord Rogers has shown that injury to the cord is possible during reduction even though there was no evidence of

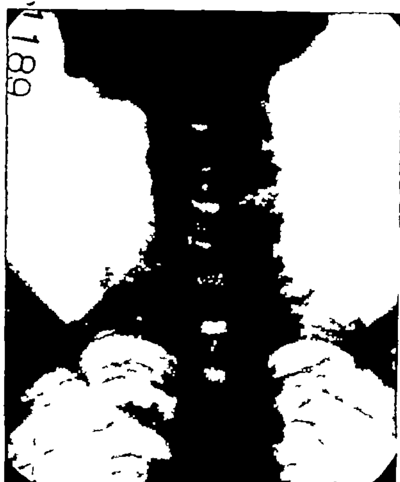


Fig. 88-A This is a case of fracture of a cervical vertebra with bone fragment impinging on the cord. Fragment not demonstrated by x rays as shown in AP and lateral views. *(Albee case.)*

cord or root pressure at the time of injury He suggests that when there is lateral displacement no attempt should be made at extension until the articular processes are in line

The roentgenograms may show only moderate displacement of the vertebrae at the time of examination while the cord is completely severed or the cord may be only contused from marked displacement Clinical examination cannot give positive evidence as to the extent of

cord damage, and the Queckenstedt test is not infallible The authors are of the opinion that laminectomy should be undertaken even though x rays may indicate severe compression or comminution of the column The operation when correctly done is not dangerous, and such fracture patients are not often in shock unless from other injuries An opera



Fig. 88-B. Same case as Fig. 88-A. Lateral view Fragment not shown.

tion not only often relieves the patient of unnecessary immobilization and simplifies nursing care, but prognosis can be more accurately determined in this way and if the cord is found to be irrevocably damaged, the patient can be told definitely what to expect and will make the necessary adjustments more readily

In selected cases seen late, laminectomy is also indicated The patient and the family are told that no result can be promised but some improvement may be expected in rare instances The authors have had sev

eral cases in which there has been marked return of function after many weeks No fatalities from the operation have been encountered and the families have been satisfied that everything possible has been done.

Open reduction has been recommended by several authors recently for those cases with locking of the articular processes This is a very



Fig. 88-C. Same case as Figs. 88-A and 88-B. Showing area of laminectomy where bone fragment was removed which was impinging upon the cord.

difficult and dangerous procedure, and is often impossible without excision of one or both of the articular processes It should not be attempted by those not adequately equipped.

Rogers well states that at present open reduction is the safest and most efficient method of treating those cases in which the vertebral body is displaced forward and the articular processes are not in line. He considers extension dangerous Open reduction employing flexion

rotation and extension in the order mentioned, is the course of procedure For those cases presenting lateral displacement of the centrum traction and manipulative replacement medially with or without extension, is indicated—as the articular processes are often fractured and probably will not lock A general anesthetic should not be given, as it is important to watch the patient for further cord damage during reduction Dislocation of the upper thoracic vertebrae should be subjected to immediate open reduction

Watson Jones advises his usual routine of postural reduction and immobilization in a plaster cast for fractures of the lumbar region with paraplegia Every precaution is taken to prevent pressure sores and a new cast is applied as soon as recovery from the nerve lesion permits In those cases in which early recovery from the paraplegia is not expected, the treatment used for dorsal injuries with complete paraplegia is suggested Fractures in the dorsal region may be reduced by laying the patient face down on a firm table, with the spine extended by pillows and sand bags The leg suspension method of Davis may be used if the general condition of the patient permits

Following reduction a posterior plaster shell is made of quick setting plaster The shell is well padded and the patient is placed in the shell and immediately turned on his back Again every precaution is taken to prevent bed sores and the use of skeletal traction with Braun s splints is advised If the paraplegia disappears within a few weeks the ordinary circular plaster cast is applied but if the nerve lesion remains complete or no hope of recovery is expected the immobilization is discontinued after from eight to ten weeks In those cases of lumbar fracture-dislocation with bilateral dislocation the lateral shifting of the spine may lock the articular processes An open reduction with excision of one or both of the processes is indicated

Laminectomy is indicated in early cases, in those rare instances in which the lamina or spinous process is driven into the neural canal producing cord compression and symptoms In several cases the x rays did not show this condition preoperatively Laminectomy may also be justifiable in cases of early cauda equina paralysis which fail to show early recovery In the later stages laminectomy may be indicated for

the untreated comminuted fracture involving the neural canal and presenting delayed paraplegia

Dunlop feels that every case with paralysis should have the advantage of reduction, in the hope that permanent damage has not yet taken place The procedure of manipulation and fixation should be planned for each case, and every precaution should be taken to determine the cause of the paralysis before treatment is undertaken

Complications The problem of after-care when there is paraplegia is of utmost importance, and the danger of complication is most important within the first few weeks of injury See page 72 for details of such care.

It is very important to keep up the patient s morale, and rehabilitation must be started as soon as possible The continued use of braces and supports when not essential prolongs the disability

Fractures of the Transverse Processes

Fractures of the transverse processes are quite common, and usually result from indirect violence as in unusual muscle contracture Rarely do they result from direct force The immediate pain and local tenderness are quite severe but it is often advisable not to tell the patient he has a broken back because of psychological effects

The x ray interpretation of fractures of the transverse processes may be difficult, due to the frequency of anomalies in this region A common error is the interpretation of shadow at the edge of a muscle or an accessory rib or an anomaly of fusion as a fracture This is important from a medicolegal angle, and can be differentiated by the smooth clear-cut line of cleavage rounded character of the bone edges and the sclerotic changes at the periphery of the anomalies as compared to the jagged line of fracture, also by additional x rays with the anode of the x ray tube differently placed

The authors contend that these fractures rarely unite due to the low osteogenic power of vertebral bone and in only five per cent of the cases can union be certain to occur although they lie in favorable surroundings that is in vascular muscle

Damage to the soft tissues with the resulting hematoma may be severe but the injury is usually not grave However due to the low

osteogenesis in this region, a circular plaster cast is advisable for from four to six weeks, allowing the patient to be ambulatory after the first three weeks On removal of the cast, physical therapy and exercises should be instituted

Such injuries are of a minor nature and firm adhesive strapping re newed at five day intervals, with rest in bed for one or two weeks is advised When several processes are broken exercises should be started when healing is well advanced—usually in two or three weeks and a belt should be worn for from one to two months

Dunlop advises rest in bed with special instructions to keep the legs quiet so as to prevent muscle pull on the detached fragments Confine ment in bed for from two to three weeks for single fractures, and for from four to seven weeks for multiple fractures is considered necessary

Fractures of the Spinous Processes of the Lumbar Dorsal Region

Fractures of the spinous processes may be the result of direct or in direct violence, and are often associated with more severe damage to the vertebral column When there is a complete fracture at the base they do not unite in many instances due to the low osteogenesis of verte bral bone and it is for this reason that the senior author has always advocated the fracturing of only one-half of the process, when inlaying a graft for spinal fusion

Fractures of the Articular Processes

Fractures of the articular processes are not unusual but their detec tion is often difficult Mensor has shown by the use of oblique x rays that many such fractures may be demonstrated and that failure to rec ognize them may be the cause of persistent low back pains

Articular process fractures may occur alone or may be associated with more severe vertebral damage Suspicion of such a fracture should be aroused when there has been a flexion or extension injury accompanied by torsion of the spine

Spies found from an extensive survey that fractures of the articular processes rarely unite, and this is confirmatory of Willis contention that

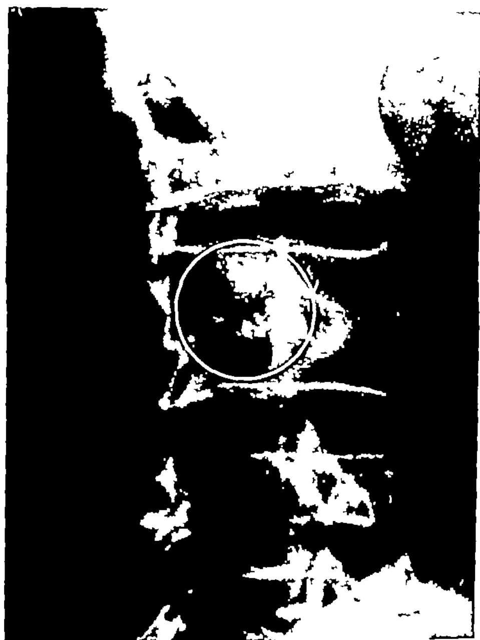


Fig. 89-A. Torsion injury followed by fracture of the inferior articular facet of a lumbar vertebra. *(From Journal of Bone & Joint Surg., Vol 19 1937)*

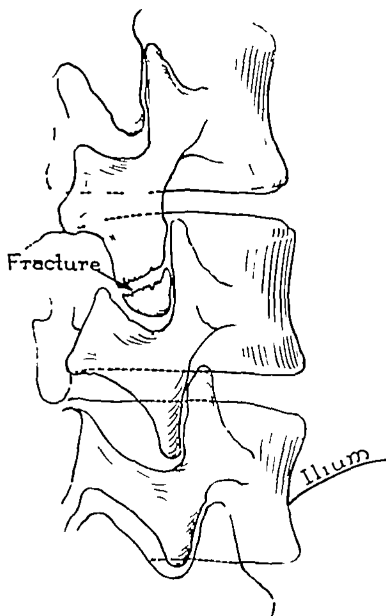


Fig. 89-B. Diagram of x ray preceding to show the irregularity of the fracture, and to show the rotation and displacement of the caudal fragments. *(From Journal of Bone & Joint Surg.)*

vertebral bone has a low power of osteogenesis. Malunions are very difficult to diagnose in this region—and often impossible to diagnose due to the resemblance to anomalies but when persistent pain fails to respond to conservative treatment spinal fusion may be necessary

Suspicion should be directed toward the articular facets and attempts made to determine the complete extent of damage by oblique roentgenograms Longitudinal splitting fractures are seen especially in the lumbar region and the tearing of the ligaments may be extensive

When the fracture is uncomplicated rest in bed for three or four weeks is usually sufficient Suturing of the lacerated ligaments is not often necessary If there is evidence of moderate dislocation or fracture of the articular facets hyperextension with the application of a circular plaster cast is required Physical therapy should be instituted immediately upon the removal of the cast

Fractures of the Sacrum

Fractures of the sacrum are usually the result of direct violence Nerve root damage is rare, because the apertures are much larger than the nerve roots The entire spine should be examined for fractures elsewhere, commonly due to indirect violence

Rest in bed with partial immobilization is usually sufficient for minor injuries Traction and the strapping of the lower back with adhesive, may be necessary For the more severe fractures a double spica cast extending from the crest of the ilium to the knee may be necessary for from six to eight weeks Open operation is rarely necessary

Fractures of the Coccyx

These are the result of direct violence and are often accompanied by severe disability Early treatment should include rest in bed and external heat Manipulation of the fragments into position followed by rest in bed is often of value Excision of the fragments may be necessary in late cases However uniformly good results are rare from operative procedures Physical therapy including massage hydrotherapy hot sitz baths gentle manipulations and instruction in correct sitting posture will often give relief

Gunshot and Stab Wounds of the Spine

The subject of gunshot and stab wounds of the spine is a very general one and shall be dealt with accordingly Two factors are of prime importance in consideration of such wounds 1 Has the spinal canal been opened? 2 If so is there injury to the contents of the spinal canal?



Fig. 90-A. X rays of lumbosacral region of the spine showing bullet in the arachnoid space In this instance the lumbar and sacral plexuses were partially permanently damaged, resulting in partial paralysis of the weight-bearing abductor muscles at both hips. No relief from removal of the bullet. Locomotion much improved by bone-graft lengthening of both kinesiologic hip levers upon which these muscles function. *(Albee case)*

In those cases in which the spinal canal is opened without injury to its contents there is always the danger of hemorrhage and meningitis However in the majority of cases, the cord is damaged to some extent Added to this, vertebral fractures from a bullet wound are compound and are accompanied by all the attendant dangers of infection from such a wound Even in those cases ...

is often severe concussion and shock. In many instances, a large vessel is torn with fatal hemorrhage From a medicolegal standpoint, it is well to note the size of the bullet its points of entrance and exit, and the presence or absence of powder marks.

Treatment Most military surgeons are of the opinion that it is best to leave a bullet wound alone, merely painting it and its surrounding skin



Fig. 90-B. Same case as Fig. 90-A.

with iodine and applying a sterile dressing No attempt is made to extract the bullet if the cord is not in danger and there are no symptoms. In most of these cases where there is no urgent necessity, it is probably better to defer operation However x rays should be taken in every case and if the x rays reveal the presence of bone splinters and there are attendant symptoms of cord compression, operation should be performed It should



Fig. 91 A. X-rays showing bullet between fourth and fifth lumbar vertebrae. In place 14 years. Shows almost complete fusion between the two vertebrae with no cord damage *(Albee case.)*

always be realized that the x rays are not as dependable in such cases as in ordinary fractures of the column because fragments of largely cancel lous (low density) bone may be carried into the canal and may not be shown. Therefore in those cases where the cord may be destroyed it is



Fig. 91 B. Same case as Fig. 91 A.

best to perform a laminectomy to remove the bullet and bone splinters. The prognosis in these cases depends directly upon the extent of damage to the cord and the incidence of infection In all these cases it is also of the utmost importance to give maximum prophylactic doses of tetanus anti toxin.

Stab Wounds

Stab wounds penetrating the spine are rare, but it occasionally happens that a sharp instrument fractures a portion of a vertebra even entering the



Fig. 92. Bilateral section of the cauda equina by a piece of shrapnel. Periradicular hematome destructive lesion of the cord. Note the perforation of the dura on the anterior aspect of the cord between the roots in the center of the lesion. *(Lévy and Collé.)*

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canal and severing the cord Each case from the operative standpoint presents its individual problem. For this reason an x ray examination is of prime importance Lumbar puncturing is also of value in revealing the presence or absence of blood in the spinal fluid There have been a few cases of osteomyelitis resulting from bullet or stab wounds reported in the literature

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CHAPTEP VI

Tuberculosis of the Spine

Etiology

Tuberculosis of the spine (Pott s disease or spondylitis tuberculosa) was first accurately described by Percival Pott in 1779—hence the name *Pott's disease* It was not, however until 1882 after Robert Koch had made his discovery of the tubercule bacillus, that its etiology was definitely determined. At present the term includes only those cases of kyphosis where the deformity is due to a tuberculous infection of the bodies of the vertebrae, and does not include angular deformity due to other diseases

Age and Sex Tuberculosis of the spine is essentially a disease of early childhood, and occurs most frequently between the ages of 5 and 10 It is slightly commoner in boys than in girls, although sex is of little importance as an etiological factor

Predisposition The spine is more often the seat of tuberculous disease than any other single bone or joint

Heredity Statistics vary considerably on this point, and can be only estimated, although there is undoubtedly some hereditary tendency or predisposition.

Injury In a certain number of cases, there is a history of an injury or trauma, although too often this history is more imaginary than real, for the injury quite often would never have been noticed if it had not been for the sensitiveness from tuberculous disease already existing in the spine

Pathology

The tubercle bacillus carried by the blood stream finds lodgment and sets up the tuberculous process practically always in the cancellous tissue of the body of the vertebra Occasionally however the tuberculous process begins in one or more of the component parts of a vertebra The dorsal region of the spine is the part most frequently affected and the

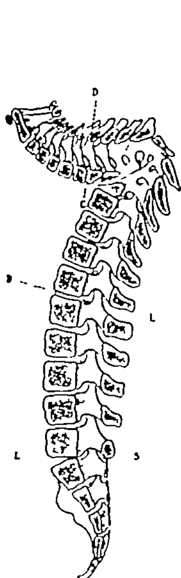


Fig. 93. Destruction of the bodies of the third, fourth, fifth, sixth, and seventh dorsal vertebrae partial destruction of three others. *(Menard)*

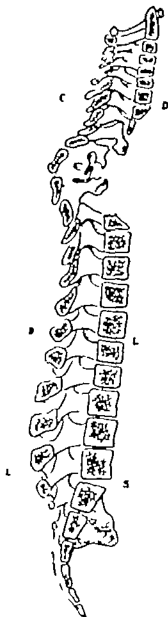


Fig. 94. The deformity corrected showing the area of the destructive process. *(Menard)*

eighth to the twelfth dorsal vertebrae are those most often involved in the tuberculous process, of which there are four chief kinds

1 *Central Variety* In this type, by far the commonest, the tuberculous process is in the body of the vertebra.



Fig. 95 Tuberculosis of the spine and of the right hip, of unusual character Flexion deformity of the hip gave rise to lumbar lordosis of such severity that the skin over the gluteal muscles was brought into firm contact with that over the kyphosis of the lower dorsal spine from the point indicated by the arrow backward to the tip of the kyphos.

2 *Epiphyseal Variety* The infection in this variety begins in the epiphysis of the body close to the intervertebral disc, and from there spreads into the disc, or into the body of the vertebra

3 *Anterior or Peripheral Variety* In this variety the primary focus is located in the anterior part of the body beneath the anterior common ligament

4 *Appendageal Variety* This type is quite rare, although occasionally the appendages are the seat of the involvement, and this is especially true of the transverse processes

Structural Changes The essential pathological process is much alike in all varieties The central variety being the form most frequently met it will be described as the typical picture.

As a result of obliterating endarteritis consequent upon tuberculous toxemia the primary change is a disturbance of nutrition of the vertebral body The marrow changes from red to a pale myxomatous structure providing an ideal soil for the growth of the tuberculous follicles These follicles increase in size coalesce, and central caseation occurs The gray myxomatous marrow of early malnutrition takes on a different aspect— the central yellow caseous area is surrounded by a gray zone limited by a thin peripheral shell of red congested marrow The lamellae become rarefied, and varying degrees of absorption occur If they become isolated before absorption is completed they form sequestrae A striking phenomenon during the elaboration of the tuberculous focus is the constant tendency of the marrow to become fibrous Subperiosteal new bone is practically never laid down except in the later stages of the disease. Tuberculosis seems to inhibit new bone formation, in contrast with the formation of subperiosteal new bone in all other infections. When the centrum of the vertebral body becomes caseous, the superimposed weight of the spinal column is borne by the fragile peripheral shell of compact bone With the fulcrum (the articular processes) and the long arm of the lever (the laminae pedicles and transverse processes) intact, and the short arm (the body) diseased, the latter gives way and descends, while the long intact arm ascends causing the tips of the spinous processes to be separated widely and producing the angular deformity common to this defect as a kyphosis The leverage action is aided and the deformity increased by overaction of the irritated anterior muscles lying on each side of the spine

Accompanying Changes Although the kyphosis is the essential deformity there are compensatory curvatures and lateral deviations of the vertebral column which also occur and quite often mechanical changes



Fig. 96. Roentgenogram of the dorsolumbar spine showing the bodies of the vertebrae *B* and *C* completely obliterated and one directly above and below thinned and wedge shaped due to the tuberculous process. The resulting kyphotic angle of the spine thus produced should be noted. The principal feature however of this roentgenogram is that no repair by bone proliferation is shown, although the destructive lesion in this case had existed for not less than three years. The need of the implantation of bone is apparent.

in the thorax and pelvis as well as frequent abnormalities of the heart and great vessels

Kyphosis The character and the amount of the kyphosis depend upon two factors—the number of diseased vertebrae and the location of the disease If only a single vertebra is involved the angularity is sharp and

the deformity slight If, on the other hand, several vertebrae are diseased, the dorsal prominence is rounded and the deformity greater The character and degree of the kyphosis in the different regions of the spine are as follows




Figs. 97 A and 97 B. A very acute case of tuberculosis of lumbar spine—three months after bone graft was inserted. The excellent spinal function is shown by first figure which illustrates static posture and second figure, flexion posture *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

1 In the Cervical Region Slight deformity The roots of the pedicles prevent inflexion of the spine Hyperextension however is possible because of the considerable space between the posterior arches

2 In the Dorsal Region Here the greatest deformities of all occur The reasons for this are that the physiological curve is posterior and the

location of the pedicles in the posterior surface of the vertebrae and the close approximation of the laminae and spinous processes prevent hyper extension

3 In the Lumbar Region The deformity of kyphosis in this region is seldom marked as the large intervertebral spaces between the bodies, and



Fig. 97-C. X rays Results 33 years after Patient has not had spinal symptoms for the past 32 years, and came for re-examination to determine whether it would be safe for him to go into military service. It was. The graft in the above illustra tion is extremely well visualized.

the wide intervals between the laminae and spines of the adjacent vertebrae readily permit of hyperextension. There is usually some vertical shortening of the spine.

Compensatory Curves 1 In Cervical Disease The compensatory curve in this region is a backward curve with alteration in the axis of the skull

2 In Dorsal Disease The compensatory curve here is a cervical and lumbar lordosis

3 In Lower Lumbar Disease There is a compensatory hyperextension of the hips in this type Lateral curvature—most often resembling a simple non tuberculous scoliosis—also occurs at times and is occasionally found complicating kyphosis This is caused by two factors—unilateral disease of the vertebral bodies, and when in the collapse of the diseased vertebrae the upper do not fall true upon the underlying vertebrae.

Changes in the Thorax Here, too there are three varieties of deformity depending upon the location of the disease and the kyphosis

1 Where the curve is high up in the dorsal region the true ribs are held at a greater angle than normally thus displacing the sternum downward, and diminishing the anterior posterior diameter of the thorax

2 When the disease is low down in the dorsal region the chest is barrel shaped and is held in the position of inspiration, with the sternum and the ribs raised and the anterior posterior diameter of the chest lengthened Patients with this type of disease are most often short of breath because their breathing is diaphragmatic

3 When there is involvement in the lumbar region, the whole thorax tends to sink forward and downward the ensiform cartilage approximates the symphysis pubis and the lower ribs may override the pelvis

Abnormalities of the Pelvis Due to the angulation of kyphosis in the lumbodorsal and lumbosacral regions, the following compensatory pelvic deformities occur

1 In Lumbodorsal Disease There is a rotation of the sacrum—its upper half backwards its lower half forwards There is also a flaring of the iliac crests and an increase in the anteroposterior and transverse diameters of the pelvic inlet with the diminution of the pelvic outlet by the encroachment of the lower half of the sacrum causing the pelvic cavity to become funnel shaped

2 In Lumbosacral Disease There is a rotation of the sacrum on its transverse axis and the pelvic outlet is diminished because of the encroachment on its cavity by the lower half of the sacrum Thus the normal obliquity of the pelvis is greatly diminished in some cases and there is a

marked decrease in the normally acute posterior lumbosacral angle, which places the long axis of the lumbar spine and the sacrum more nearly in the same vertical plane

Abnormalities of the Heart and Great Vessels In tuberculous disease of the mid-dorsal region, the heart is quite often affected. Usually hyper trophy occurs as a result of the sinking of the aorta with the consequent constriction Ultimate dilatation of the left ventricle follows



Fig. 98. Tuberculosis of the spine showing the progressive disintegration and collapse of the vertebral body primarily affected, the infection of the contiguous vertebrae by contact, and the mode of production and growth of a prevertebral ichor pocket (cold abscess) *(After Cabot)*

Effects on the Spinal Cord Even in cases where there may be a great angular and kyphotic deformity pressure symptoms on the spinal cord are most rare If compression paraplegia does occur it will be found most often to be due to packy meningitis or the encroachment of tubercular granulations, an ichor pocket or to partial dislocation of the vertebrae, or the pressure of a sequestrum

Abscess Formation or Ichor Pockets An ichor pocket (cold abscess) is the commonest complication of Pott s disease It occurs in approximately 20 per cent of the cases The term *ichor pocket* was first suggested by Dr Achilles Rose of New York, and was first used by Dr H L. Taylor It is used to designate fluid debris. An ichor pocket or tuberculous abscess is formed by the perforation of the investing shell of bone or by the dissemination following collapse of the vertebral bodies The course which an ichor pocket or abscess will follow is determined by the planes of fascia and other anatomical structures in its vicinity as



Fig. 99-A. Tuberculosis of second cervical vertebra. (Dr Reginald H Sayre.) Marked distortion and extreme torticollis. *(From Albee Orthopaedic and Reconstruction Surgery W B. Saunders Co., Philadelphia.)*



Fig. 99-B. Attitude of head in cervical Pott's Disease. *(Bradford and Lovett.) (From Albee Orthopaedic and Reconstruction Surgery W B Saunders Co., Philadelphia.)*

1 In the Cervical Region An ichor pocket or abscess in this region is directed entirely by the disposition and arrangement of the deep cervical fascia, and may appear as follows

(*a*) It may collect between the anterior surface of the cervical vertebrae and the prevertebral fascia. It may bulge forward as a retropharyngeal ichor pocket. Or it may spread laterally to the posterior edge of the sternomastoid muscle.



Fig. 100. Cervical disease. A characteristic attitude (*Whitman.*)

(*b*) It may penetrate the prevertebral fascia and may appear in the mouth or around the esophagus and the trachea It most frequently however gravitates downward to the mediastinum or axillae

(*c*) It may lie between the spines and the ligamentum nuchae on the inner side, and the posterior cervical muscles on the outer side.

2. In the Dorsal Region In this region the abscess is usually small and found in various locations

(*a*) It may remain between the vertebral body and the anterior common ligament or it may follow the same course as was given for pockets



Fig. 101 Psoas abscess. *(Bradford & Lovett)*



Fig. 102. Lumbar abscess. *(Bradford & Lovett)*

of the cervical region. This is particularly so in the upper four dorsal vertebrae

(*b*) It may perforate the anterior common ligament, and invade the posterior mediastinum

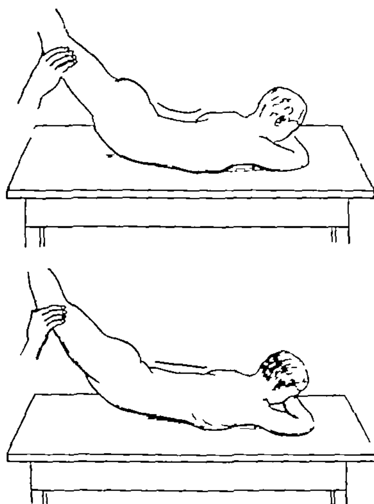


Fig. 103 *Upper* Shows extensibility of the spine in a normal individual. *Lower* Illustrates the muscular rigidity ("boarding") of the back on passive extension of the spine.

(*c*) It may extend laterally and come to lie beneath the pleura or penetrate into the pleural cavity and form a tuberculous empyema

(*d*) It may gravitate downward and appear in the lumbar region

(*e*) It may extend backward between the transverse processes

(*f*) It may extend forward with the intercostal vessels

(*g*) It may follow along the nerve trunks, paralleling the internal or external branches of the posterior primary divisions

3 In the Lumbar Region An ichor pocket arising in the lumbar region is directed principally, and has its focalizing point as follows

(*a*) It may follow the sheath of the psoas muscle beneath Poupart s ligament, and point at either the inner or outer side of the femoral vessels

(*b*) It may follow the sheath of the psoas muscle for a short distance, and then extend outward under the iliac fascia and point as an iliac abscess or ichor pocket

(*c*) It may extend forward, behind the aorta and downward, following the great vessels and ultimately follow along the external iliac artery

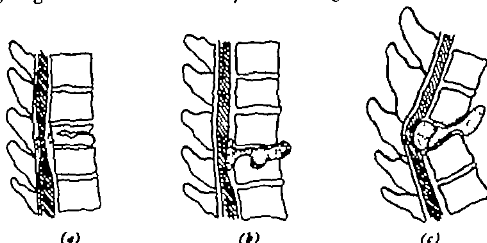


Fig. 104. The three usual causes of paralysis in Pott s disease. (*a*) Dislodgment of a disintegrated fragment of vertebral body and pressure therefrom upon the cord the same effect would be produced by posterior dislocation of the entire vertebral body (both causes rare) (*b*) The escape of an ichor pocket into the epidural space and compression of the cord between it and the neural arch. (*c*) Pachymeningitis caused by extension of infection from the subjacent osseous lesion. (*After Cabot*)

to points in the thigh or along the internal iliac artery to points in the pelvis or it may open into the rectum or into the great sacrosciatic foramen.

(*d*) It may follow the sheath of the quadratus lumborum and point in Petit s triangle

(*e*) It may extend along the dorsal branches of the lumbar arteries appearing close to the spine and the last rib

(*f*) It may extend between the planes of the abdominal muscles and appear in the anterior abdominal wall

(*g*) It may extend along the nerve sheath to a point some distance from the midline.

Rare Forms of Tuberculosis of the Spine

Although tuberculous disease of the vertebral body, as discussed above, is the predominating lesion other unusual tuberculous involvements do occur, namely

1 Spondylarthritis This is tuberculous disease of the occipito-atloid and the atlo-axoid articulations It begins as a synovial tuberculosis but soon spreads to the adjacent bony structures

2 Tuberculosis of the transverse processes

3 Tuberculosis of the costal vertebral articulations

4 Tuberculosis of the spinous processes

5 Tuberculous involvement of the joints of the articular processes

Discussion of the Physical Signs and Symptoms of Tuberculosis of the Spine

Although the greater number of cases of tuberculosis of the spine present no great difficulty in diagnosis there are times when all the diagnostic points vary tremendously It is for this reason that when the patient first presents himself for examination, one must and should go *into the greatest detail as to present illness and family history* This should be followed by the most complete physical examination that can be given with a detailed x ray examination—including the taking of anteroposterior lateral oblique and stereoscopic views—as the final step

The following is a summary, grouped by regions *of the most frequent signs and symptoms which occur and when found together with* or without x ray evidence are almost conclusive evidence of tuberculosis of the spine

Signs and Symptoms of Disease in the Cervical Region

1 Muscle spasm with consequent difficulty in moving the head

2 Pain which may be local over the spine, or may be referred to the back of the head and along the upper cervical nerve

3 Pain on pressing upon the vertex

4 Deformity—quite often resembling wry neck

5 *Abolition or limitation of nodding and rotation of the head*

6. Obliteration of the suboccipital hollow in some cases

7 Supporting of the head in the hands because of great pain

8 Ichor pockets, if present of the retropharyngeal or suboccipital type

9 With cord symptoms, the usual paralysis of the arms and then of the legs If the odontoid process becomes disintegrated, dislocation of the head will follow—then death

Signs and Symptoms of Disease in the Cervical and Cervicodorsal Region

1 Marked rigidity associated with wry neck, shortening and angular kyphosis

2 Diminution of the anteroposterior diameter of the thorax The ribs are held vertical

3 Pain if present, following the branches of the cervical and brachial plexuses

4 Ichor pockets if occurring of the retropharyngeal subclavicular or medial spinal types

5 Cord symptoms if present, first affecting the arms and then the legs

6 Nerve pressure symptoms

(*a*) Pupillary symptoms (miosis or mydriasis) from pressure on the sympathetic nerves

(*b*) Recurrent pharyngeal and vagus symptoms (coughs slow cold vomiting etc.)

7 Characteristic attitude—head and body turning as one to look at an object

8 Breathing of a grunting type because of pressure on the intercostal nerve

Signs and Symptoms of Disease in the Dorsal and Dorsolumbar Region

1 Muscle spasms and the characteristic kyphos

2 Pain radiating to the outer side of the thigh

3 Neuritis affecting individual groups of muscles

4 Localized vertebral thickening

Signs and Symptoms of Disease in the Lumbosacral Region

1 Deformity usually slight rarely a spondylolisthesis

2 Pelvis deformed—funnel shaped in children

3 Vertebral thickening
4 Neuritis, if present, of local distribution
5 Pain referred to the outer side of the thigh

Diagnosis

When there is a marked kyphosis present, there is usually little difficulty in diagnosing the disease However, many of the most puzzling cases are those in which there are compression symptoms without any vertebral deformity A history of local and referred pains particularly in the arms or legs or in the anterior midline, and which are either sternal or epigastric, are highly suggestive of the disease The physical examination usually reveals muscular spasm—active or passive—and an aggregation of signs of the above kind is strongly indicative of Pott s disease Ichor pocket formations may be present, and may be one of the first signs of the disease. An early spastic paralysis may be an initial sign of the disease. The tuberculin test is of considerable value in diagnosis and lastly there is the indisputable evidence revealed in x ray examination

Differential Diagnosis

Region	Disease	Points of Resemblance	Points of Difference
CERVICAL REGION	Torticollis.	Abnormal posture of head and neck.	No pain on motion. Shortened sternomastoid muscles, rotation of face to opposite shoulder hemiatrophy of face. X-ray Cervical spine flexible
	Torticollis due to acute arthritis of cervical spine following acute infection.	Abnormal posture of head and neck, rigidity pain on movement, etc	Acute history Rapid subsidence under treatment. X ray Metastatic infection from tonsillitis, etc
	Round shoulders, with stiffness.	Stiffness causes restricted motion. Absence of pain (adolescent tuberculous spondylitis)	No muscle spasm X ray negative. Long duration. Postural history Absence of neuralgic pain.
	Fracture or fracture dislocation, cervical vertebrae	*Torticollis Kyphotic deformity with stiffness and weakness Pain. Paralysis.*	*History of the injury with acute symptoms following. X-ray*
	Typhoid spine.	Pain weakness nd stiffness of the neck	Typhoid history with onset in its later stages. X-ray
	Arthritis deformans, with or without cervical kyphosis.	Pain and stiffness in neck.	Chronicity Relief from recumbency at night, Marked difference in X-ray findings.
	Sarcoma.	Local pain Paralysis. Deformity	Rare in childhood All symptoms more severe Palpable tumor Paralysis frequent early and rapidly progressing X-ray
	Hysteria.	P in and stiffness in back and neck.	Pain does not follow nerve distribution, with several points of intensity—anesthetic reas. Other hysterical stigmata. X-ray

Region	Disease	Points of Resemblance	Points of Difference
Dorsal Region	Rachitic kyphosis.	Kyphotic deformity	General rachitic stigmata. Sits erect without discomfort. Kyphos rounded and reducible. Absence of muscle spasm. Pain slight or absent. X ray
Dorsal Region	Scoliosis.	Distortion of the spine	Absence of muscle rigidity and pain. Typical posterior rib hump. Ribs rotate backward on convex side. X ray
Dorsal Region	Syphilitic kyphosis.	Local deformity and local symptoms.	Rare. General manifestations of syphilis. X ray shows marked bone proliferation
Dorsal Region	Spinal neuralgia.	Pain in the back.	Pain more diffuse and over a large part of vertebral column, is more superficial and more acute. Rigidity entirely absent. Subjects are *neurotic young girls*. X-ray
Dorsal Region	Anatomical anomalies.	Abnormal prominence of one or more vertebral spines, resembling a kyphosis.	Physical examination negative except for the pseudo-kyphos. X ray
Dorsal Region	Typhoid spine.	As in cervical region	
Dorsal Region	Arthritis deformans.	As in cervical region	
Dorsal Region	Sarcoma	As in cervical region	
Dorsal Region	Hysteria.	As in cervical region.	
Dorsal Region	Gonorrheal spondylitis.	Pain, weakness, stiffness of back.	Rare. Ankylosis common. Urethral discharge stops when spinal involvement begins. X-ray
Dorsal Region	Paralysis: Diphtheritic.	Attitude. Localized. Muscular weakness.	History of diphtheria with symptoms following. Absence of symptoms of spinal caries.
Dorsal Region	Paralysis: Cerebral spastic paraplegia.	Spastic condition of the muscles. Gait. Reflexes increased.	Absence of pain. History. Mental impairment. Absence of symptoms of spinal caries.
Dorsal Region	Paralysis: Cerebrospinal meningitis.	Contractions, weakness and pain. Reflexes increased.	History of the case. Meningitis with symptoms following.
Dorsal Region	All the preceding dorsal spinal affections.		
Dorsal Region	Hip-joint disease.	Limp (psoas-contraction). Flexion of the thigh.	Limp usually late symptom. No spinal symptoms. Pain on functional use. All motions at hip limited.
Lumbar Region	Sacro-iliac disease.	Pain and sensitiveness of lower spine	Pain and tenderness *localized* at joint. Movements of spine not restricted. Uncommon in childhood. *Great restriction of motion of hip*
Lumbar Region	Perinephritic and peri typhlitic abscesses.	Motion of spine restricted. Swelling in inguinal region. Contraction of psoas muscle	Acute onset. Constitutional disturbances. Local tenderness. Voluntary spinal restriction. Preceding history. Positive findings on spinal, *abdominal*, *urinary* and X ray examination
Lumbar Region	Strain of back.	Stiffness and pain on motion.	Sudden onset. Cause known. Pain localized at point of injury. Relieved by rest. Restriction of motion voluntary
Lumbar Region	Pseudo-hypertrophic muscular dystrophy	Attitude. Weakness or lordosis.	Absence of pain, kyphosis and muscular rigidity. Extremely slow onset. Gait waddling, awkward. Years. Knee jerks diminished or lost.
Lumbar Region	Lumbago.	Stiffness and pain.	Sudden onset. Local pain. Sensitive *muscles*. Uncommon in childhood.
Lumbar Region	Sciatica.	Pain referred to legs (both)	Pain *unilateral* and confined to distribution of the nerves which are sensitive to pressure. Movements of legs painful, spine painless. Uncommon in childhood.

Treatment

The universally accepted theory of the treatment of general tuberculosis, regardless of parts affected, is complete rest This is especially true of the osseous system It is axiomatic in orthopedic surgery that an ad



Fig. 105 View of a dog's vertebra into the spinous process of which a portion of his ulna had been ingrafted by the author six months before. *A B* and *C* indicate the outlines of the graft, which has become firmly grown into the split spinous process. *E* is articular facet. (*From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.*)

vanced destructive tuberculous lesion in a joint can never be said to be cured except where ankylosis has taken place Without ankylosis, the danger of a relapse is always present

It was this need for a technic of ankylosis that led the senior author in 1909 to undertake research on the trustworthiness and permanency of the implantation of bone into the animal spine Having observed how nature



Fig. 106. Longitudinal section through spinous process with cross-section of graft (*ABC*) which had been inserted six months from a low power photomicrograph of a non-decalcified ground specimen. Numerous blood vessels can be seen, under high magnification, extending from spinous process into graft. *D* is new bone. *E* is base of spinous process. *From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

in rare instances produced fusion and arrested disease by supplying new bone, the author deduced that it might be possible for the surgeon to duplicate this method by inserting the necessary bony bridge Upon experimentation it was found that the implantation of a part of the tibia

of a dog into the spinous processes of the same animal, in the absence of violent infection, produced universal fusion

Next came the step of carrying the work to the human, in whom now for over 35 years the bone graft method of fusion has proved most dependable—not only in tuberculosis of the spine, but equally in all joints involved in a tuberculous process



Fig. 107 Decalcified section through long axis of spinous process with cross-section of the grown in graft, six months after a portion of same animal's ulna had been grafted into spinous processes. A careful microscopic study of these sections and all others had failed to disclose dead bone cells. The corners of the graft are indicated by *a* *b* and *c* (*d* is a microtome artefact) *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

So it was that *surgical immobilization* came into being and with it a new phase in the treatment of all tuberculosis including pulmonary Because the osseous system is much more favorable for the production of complete immobilization, and more trustworthy conclusions could be drawn from the clinical observations, laboratory findings, and x rays con

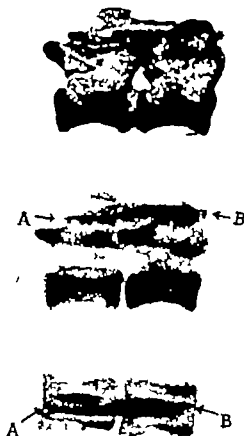


Fig. 108. Photograph and roentgenograms of an ulna autogenous graft, *AB* six weeks after being inserted into the spinous processes of a dog s vertebrae. The roentgenograms show firm union and no osteoporosis or degeneration of the graft. *From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

cerning it the value of the bone graft was recognized first. But why surgi cal methods to immobilize pulmonary tissue were so much slower in being generally adopted by the profession, is difficult to explain Artificial pneumothorax which corresponds to a splint in the treatment of tuber culous joints, as a means of producing immobilization was first suggested in 1822 by Dr Carson of Liverpool but it was not until 100 years later

that any form of immobilization by surgical means or thoracoplasty, which in turn corresponds to fusion in the tuberculous joint, became a fact in the experience of the profession and then another decade (1932) before its actual value was generally recognized As John Alexander of Ann Arbor writes Only during the last 10 or 12 years has collapse therapy been used in the leading sanatoria of the world with a full appreciation of its value and limitations and with the production of astonishingly good results. The number of patients so treated has been too small in relation to the total number of patients treated for tuberculosis greatly to affect the tuberculosis death rate It is probable that the death rate will be greatly reduced when all sanatoria use collapse therapy with maximal efficiency

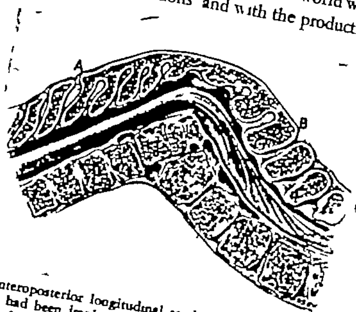


Fig. 109 An anteroposterior longitudinal section of a spine two years after the tibia bone graft had been implanted into its split spinous processes to ankylose the tuberculous infected vertebrae present between *A* and *B*.
The drawing was made from an actual specimen and represents the alteration which has taken place in the character of the graft and its bed.
The area *A* to *B* has been so changed that it presents the characteristics of a single bone with a distinct cortex enclosing cancellous bone structure throughout, or in other words, it has become identical in its anatomical structure to the spinous processes to which it has become amalgamated.
This is a fortunate characteristic of the bone graft, *i e*, it adapts itself to its environment. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

Often during the past 35 years the authors have had the painful experience of seeing the brilliant result of a surgically induced fusion of an advanced tuberculous process of a joint or joints, completely negated be

cause of the omission of efforts to control an incipient pulmonary lesion in the same patient

However, since the profession has learned more of the care of tuberculous patients and has applied the principle of surgical immobilization in the form of thoracoplasty and the bone graft, the mortality from all forms of tuberculosis has declined from second place in 1900, with a mortality of 201 3 per 100,000 population, to sixth place with 53 6 per 100 000 in 1937

In planning treatment of tuberculosis of the spine it is of extreme significance that anatomically we are dealing with joints under such uncontrollable mechanical influences as respiration involuntary muscle spasm and voluntary muscle action This fact contributes greatly to the spread of the tuberculous process and operates against cure It not only makes it more difficult for nature to set up a protective ankylotic process but also presents increasing difficulties to the surgeon who attempts to bring about immobilization by non-operative, conservative means

The authors are convinced that the advantages from good surgery are as great in bone and joint tuberculosis as in pulmonary tuberculosis and the rationale is the same.

GENERAL TREATMENT

All measures which are used in the treatment of general tuberculosis should be included in the treatment of osseous tuberculosis and especially in tuberculosis of the spine These should include a diet of wholesome food carefully prepared hygienic living conditions proper climate and heliotherapy

Diet In all forms of tuberculosis there is usually a continuous loss of weight. This can be counteracted to a considerable extent by a properly planned diet Actual forced feedings are unwise in that the enforced lack of exercise induces a derangement of the digestion with anorexia

The ideal diet is one in which fats and carbohydrates predominate, with a considerable quantity of albuminates included as well

If fever is present a fluid or semisolid diet must be given until the temperature returns to normal

The tuberculous patient should receive adequate quantities of milk, cream butter eggs and fresh red meat The milk should be sterilized or

pasteurized unless the owner or the hospital has its own herd of cows which are constantly checked for tuberculosis and other milk borne diseases Only in such instances, may pasteurization be omitted

Cream is more readily assimilated if diluted with hot water Green vegetables should be given in sufficient quantities to maintain the patient s vitamin and mineral supply Recent experiments have brought forth valuable information concerning the value of vitamins and the patient should be given the benefit of this knowledge.

The ultra modern practice of insuring vitamin content by giving attention to the production of the food, its mineralization, proper storage and preparation, as well as to its planning, should be followed. It should be realized that contact with the air during cooking destroys the vitamins present and therefore all vegetables should be cooked by the closed method whereby all air is kept away from the food while cooking thus reducing oxidation to a minimum

It has been found that patients suffering from chronic debilitating conditions such as tuberculosis often show a deficiency of vitamin C. Blood and urine tests should be made frequently to determine whether or not such a deficiency exists In cases of deficiency, the diet should be adjusted to include the additional vitamin requirement with or without the giving of the vitamin in concentrated form

Cod liver oil may also be given in considerable quantities, both for its high vitamin D content and for its beneficial nutritional properties due to its high percentage of fat.

Hygienic Living Conditions In many cases it is necessary that the patient receive a considerable portion of his treatment at home, and in such instances special attention should be paid to his surroundings Of primary importance is his need for fresh air An out-of-door life night and day and in all kinds of weather should be enforced Such patients especially children, develop a considerable tolerance to cold and it is remarkable the amount of cold weather they can stand Clothing should not be unduly heavy or ill fitting

Proper Climate It has long been recognized that climatic conditions play a major role in the treatment of tuberculosis of every type, and especially in the treatment of osseous tuberculosis Even if a radical change of

climate is not possible the beneficial effects of a change of air and scene are always apparent, especially in the early stages

Heliotherapy The actinic rays of the sun not only act as a powerful germicide to bacteria brought under their influence, but exert a most beneficial effect upon cases of surgical tuberculosis Care however should be taken to rule out any active pulmonary lesion before the patient is exposed to severe sun treatment. The importance of heliotherapy is emphasized by the large incidence of the disease in countries such as Norway Sweden and Denmark, as contrasted with the phenomenal recoveries in such places as Switzerland, California, Arizona, and Florida, and in fact the actual rarity of surgical tuberculosis in Florida.

Meteorological measurements and investigations have shown that in metropolitan centers such as New York, Pittsburgh St. Louis and Cincinnati, there are from two to four tons of dust per cubic mile constantly overlaying the city sufficient to filter out every vestige of the actinic and ultraviolet properties of the sun s rays

Whenever possible all cases of Pott s disease should receive heliotherapy The body should be exposed to the actinic rays of the sun for an increasing period each day until several hours of exposure can be tolerated. Remarkable improvement has been noted in the general condition of the patient and chronic tuberculous sinuses have been found to granulate more rapidly when treated in this manner

When it is not possible for the patient to receive sun treatments it is advisable for him to be exposed to ultraviolet irradiation by means of either a carbon arc or mercury quartz lamp

LOCAL TREATMENT

The profession has always attempted to secure immobilization of the tuberculous vertebrae by external means to the end that nature might repair the lesion by substituting fibrous connective tissue for the carious portions of the vertebrae Except in rare instances attempts to secure this result by various mechanical supports have proved unsuccessful as usually it has been found impossible to effectively immobilize a series of short irregular bones to which are attached muscles acting in coordination with the involuntary muscles of respiration

Because of the large size of the trunk and the fact that it includes within it the respiratory and gastrointestinal organs which are in constant motion and causing continual change in the diameter of the thorax and the abdomen, spinal braces and plaster of paris jackets are at a great disadvantage. An added objection to these imperfect attempts at immobilization is that if a cast is applied to accomplish the cure, it seriously restricts the movements of these organs and interferes with respiration, oxidation and nutrition upon which so much depends in the treatment of any form of tuberculosis.

If a cast is applied to a child during the growing period, the tendency to produce muscle and bone atrophy by prolonged recumbency and inactivity is most unfortunate anatomically and physiologically and in the opinion of the authors far outweighs any objection to submitting a child to an operation of slight magnitude with such an outstanding curative influence. Then, too, seemingly successful results from prolonged conservative treatments are so often followed in a year or so by a relapse.

The late-end results of cases in which the bone graft operation for Pott's disease was performed in early childhood have been so favorable, and the senior author has seen so many tragic cases of unsuccessful results from long conservative treatment where operation has been sought too late, that he stands emphatically for early operation. Recent literature shows that more and more surgeons are inclining toward this view.

The Bradford Frame and the block are not open to all these objections, but they have their own disadvantages, the most important of which is the protracted inactivity of the patient and the fact that one can never be certain that there will not be a relapse so long as there is no bony ankylosis.

As the body of the vertebra is made up almost entirely of spongy bone, and since the tuberculous disease is confined largely to this cancellous structure, it follows that this portion of the vertebra is involved to the exclusion of the dense or vertical bone that makes up the lateral masses and the spinous processes, thus producing the increased angular deformity or kyphosis so noticeable in these cases.

Nature in her endeavor to protect the spine when attacked by tuberculosis, resorts to immobilization of the diseased area by the only means at her command—involuntary spasm of the spinal and abdominal mus-

cles In spite of external supports this usually increases the crushing effect on the diseased vertebral bodies, with increased collapse of the spine and an extensive kyphosis

It is a rare exception for cases of Pott s disease, treated by the conventional methods of externally applied fixation, to produce solid bony union between the partially destroyed vertebral bodies And when actual firm bony fixation is not accomplished, the case cannot be considered permanently cured

Before internal immobilization by operative means was devised methods designed to accomplish this were

1 Recumbency This removes one of the chief exciting factors the superincumbent weight of the body, but must be maintained during the long period of activity of the destructive process

2 The application of plaster jackets or braces, as a further means of fixation, during or following months of compulsory recumbency on a Bradford Frame or fracture bed

Clinical evidence that vertebral bone has a low degree of reparative potentiality is shown by the following phenomenon When the lateral process is broken, although the fragments may lie in perfect apposition, and surrounded by vascular muscle they do not unite in more than five per cent of the cases According to the studies of Spies fractures of the articular process practically never unite Secondly the progressive lysis of traumatized vertebrae, as evidenced in Kümmell s disease, suggests that the bodies have little recuperative osteogenetic power and the progress of tuberculosis in the vertebral body is apparently not hindered by an adequate reparative process of an osteogenetic nature

Furthermore marked lack of reparative action is shown when the vertebral bodies are involved in tuberculosis In many instances the authors have seen as many as eight or ten vertebral bodies entirely disappear without any apparent effort on nature s part toward bone replacement X rays revealed not only the complete disappearance of these bodies but no associated bone growth or callus whatsoever

These clinical observations may be explained by the fact that embryologically because of its developmental location vertebral bone is derived from the ectoderm in which tissues of higher differentiation—

such as the optic nerve, the nerves of hearing and those of the spinal cord—all have their origin, and are similarly weak in reparative ability

Although the fact that vertebral bone has a low degree of osteogenesis may operate to great surgical disadvantage in instances such as tuberculoses, for Nature's purposes in general it is much safer than if its osteogenesis were high With a low degree of osteogenesis, spinal bone when

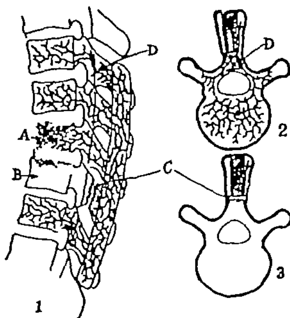


Fig. 110. Schematic representation of the supporting and vascularizing functions of the graft. The section shows the side of the gutter on which the half-spines are left intact (*D*) The circulation in the graft has linked up with that of the healthy vertebrae and with one diseased vertebra (*A*) through the intact half spine diseased vertebra (*B*) fails to obtain immediate mechanical support or revascularization because the half-spine has been fractured (at *C*) and has not reunited. This is illustrated to show the disadvantage of fracturing the second half either by accident or by design. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

involved in other disease or fracture does not pour out callus which might encroach upon the spinal cord, which it is designed to protect

Because of this inadequate callus-forming capability of vertebral bone, it is clear that in order to secure immediate strong fusion, it is more trustworthy to insert a strong single graft from a long bone of high osteogenesis than to depend upon local bone. Furthermore, a massive bone graft inlaid into the spinous processes and their ligaments, provides almost immediate immobilization of the affected vertebrae

When the senior author first used this spinal graft he used autogenous bone from the patient s tibia, for the following reasons which seemed then, and he is convinced still are in accord with the best biological principles

1 The tibia combines the greatest inherent osteogenetic potentiality with a high degree of reparative power When inlaid into the spinous processes, it not only provides excellent internal immobilization, but because of its own osteogenetic power and that of the spinous processes fuses immediately with the spinal column

2 An extremely important curative factor is the aid to vascularization of the tuberculous portions of the vertebrae furnished by the vascular canalization of the massive tibial graft which thus brings blood from the healthy vertebrae on each side to those diseased

In the long bones 75 per cent of the blood supply is conveyed by means of the marrow and endosteum In the case of such flat or irregularly shaped bones as the vertebrae, this relationship may be somewhat changed, but it is roughly in this proportion Therefore, the ideal pro cedure is to contact the graft generously with the cancellous interio of the bone of the spinous processes as well as of the rest of the vert brae, a process which should be brought about with a minimum o disturbance in the circulation of the host bone.

It was with these considerations in mind that the author designed th autogenous inlay graft for the treatment of Pott s disease and oth affections of the spine

In this operation the spinous processes as well as their embedde ligaments are split with the scalpel and osteotome as nearly as possib to the median raphe, and into this cleft or gutter the massive graft inserted

The authors believe that the amalgamation of diseased vertebrae wi the healthy ones on either side, influences the repair of the disease vertebrae in at least two ways namely increased stress with its stimul to metabolism is thus brought to bear upon the undiseased portions o the involved vertebrae with complete immobilization of one vertebra t another and the bony bridge produced by the graft acts as a vasculari ing agent, bringing blood from the posterior parts of the uninvolve vertebrae to the posterior parts of the diseased vertebrae

Such an autogenous graft is put into the split spinous processes in intimate contact with the vascular system of the vertebrae under the most favorable conditions for the vascularization of the graft and its linking with the internal vascular system of the vertebrae



Fig. 111 A and B Case of tuberculosis of the lumbar spine first operated upon December 1911, when patient was 8 years old. There were abscesses in the groin and back and two foci of disease between the second and third lumbar vertebrae, and between the fourth and fifth lumbar vertebrae. In these x-rays, thirty years after first graft is clearly visualized as is the fusion between the second and third lumbar vertebrae, and between the third and fourth lumbar vertebrae. This patient selected a life on the sea and rose to a captaincy in the merchant marine. He is now in the navy His back never interfered with any activity as a sailor—such as climbing shrouds, etc. *(Albee case)*

The immediate and profuse vascularization of the graft inserted for any condition whatsoever has been a most striking phenomenon, and the authors believe it to be largely responsible for the extremely benefi cial action of the bone graft inlaid into the spine or other tuberculous

joints, such as the knee This fact, therefore emphasizes the need for accuracy of fit of the graft into the host tissues and also the importance of using a massive graft of ample length, as such a degree of beneficial vascularization could not be accomplished by bone chips, especially those taken from the vertebrae themselves

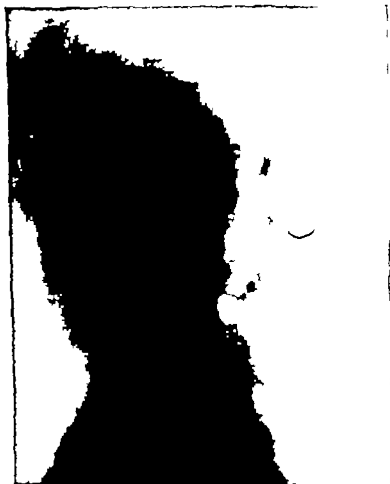


Fig. 111 B

Under such conditions the haversian canals of the graft rapidly become canalized and increase in size precisely in the same way as when an important blood vessel has been cut or occluded, and a collateral circulation is established

Because tuberculous involvement diminishes even further the inherently low osteogenetic potentiality of the vertebral bone and because the osteogenetic potentialities of different individuals vary widely, and are absolutely impossible to determine even at the operating table it is

incumbent upon the surgeon to play the game as safely as possible, and to select not only an ample amount of bone in the form of a complete splint, but to choose bone of the greatest known osteogenetic potentiality

It should be kept in mind that practically the whole spinous process is covered with ligamentous and muscular attachments and consequently there is very little actual periosteum available To rely upon the low osteogenetic potentialities of vertebral bone, particularly in the form of chips is to face an uncertain result. This uncertainty is heightened by the fact that this time-consuming method involves dealing with a number of small pieces of bone which have to be secured in a position favorable to final bony ankylosis and failure to produce ankylosis between any two vertebrae necessarily results in failure of the whole

This fact was clinically demonstrated in a series of 203 tuberculous spine cases treated by a Hibbs fusion which Dr Mather Cleveland reported recently * and from which he deduced an incidence of at least ten per cent of failure of fusion may be expected in the hands of experienced surgeons and with lesser experience, the incidence will be higher From the author s experience, this seems a most conservative statement, a fact further borne out by the statistics of Beckett, Howorth, and Garber presented at the 1942 meeting of the American Medical Association, which showed that of 600 Hibbs operations for spinal fusion *performed at the New York Orthopedic Hospital from* 1931 1935, 14 per cent resulted in failure, a figure which was increased to 18 per cent in the instances of spondylolisthesis at the lumbosacral junction

Anatomically and mechanically as the spine flexes and extends the vertebrae move through an anteroposterior plane with the articular processes serving as the axis The processes being separated by the crushing of the vertebrae, a fulcrum is afforded at the lateral facets The graft is put in posterior to this fulcrum and serves to hold together the spinous processes or the posterior (lever) arm of the vertebrae, thereby relieving all eroding pressure from the vertebral bodies which are mechanically speaking, the anterior lever arms It is a fortunate circumstance that the bones involved in this fulcrum or lateral mass, as well as the spinous processes in which the graft is implanted are because of

* Cleveland, Mather "Treatment of Tuberculosis of the Spine J Bone & Joint Surg July 1940

their cortical content, practically never affected by the tuberculous process

An important consideration in such cases is the length of time required for an operation, and the consequent shock An operation that consumes little time and induces comparatively little shock, may obviously be undertaken when the operative resistance of the patient is not of the best. The bone graft operation may be completed in as little as 15 minutes in a favorable case, if one s operating team is thoroughly familiar with the routine and the special instruments required

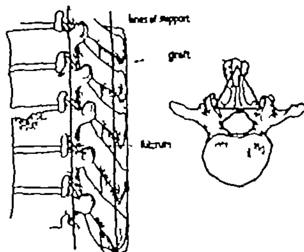


Fig. 112. The mechanical advantage of the inlay graft when placed in the tips of the spinous processes. The broad fulcrum through the lateral facets is indicated the location of the graft, and the leverage action of the spinous processes. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

Rough handling of the tissues and violent retraction at operation undoubtedly add to the shock of any operation The minimum of shock produced by the bone graft operation is due not only to its simplicity and consequent shortness of duration but also to the fact that it does not require excessive retraction, and there is no necessity to operate more or less blindly in regions difficult of access with consequent traumatization of the tissues

INDICATIONS AND CONTRAINDICATIONS FOR OPERATION

It has been the practice of the senior author for over 32 years to operate upon any patient, at any age provided the surgical risk was good The surgical risk in operations for tuberculosis of the spine depends upon several factors

1 General Condition of the Patient The authors consider the bone graft operation safe if the patient is fit for any major operation, particularly *if the surgeon is skillful and rapid and working in suitable surroundings*

Paraplegia, prevertebral and psoas abscesses provide additional indications for operation.

High temperature, due to secondary pyogenic infection is a contraindication. Before operation the bacteriemia must be allowed to subside A transfusion of blood may help

Pyrexia, due solely to the tuberculosis is not a contraindication to operation.

2. Multiple Lesions The presence of tuberculous foci elsewhere often has to be taken into consideration in determining operability The authors have observed frequently especially when the focus is in the kidney testicle or epididymis that a spinal lesion goes on to a successful issue following the operation, although the general resistance of the patient is insufficient to prevent the progress of a second focus or foci either to the point of destruction of the affected region, or to the necessity for extirpation

The authors have observed these same favorable results after operations on articular joints in the face of tuberculosis elsewhere The presence of a second tuberculous focus, even if it is progressive, is not a contraindication to operation

3 Field of Operation The presence of sinuses is not a formidable obstacle unless they are situated near the spinous processes or within the field of operation. Fortunately the anatomic cleavages are so placed that it is rare for a cold abscess ichor pocket to point in the region of the spinous process although it may point close enough in the loin to the field of operation to demand special care The skin must be thoroughly prepared, and the sinuses sealed with a collodian tampon before the operation is begun The indication for operation is increased when *an abscess or sinus is present.* In several cases, the authors unexpectedly encountered an ichor pocket deep down in between the spinous processes In none of these cases did it interfere with the union of the graft or the course of convalescence

4 Age of Patient The bone graft operation has been more readily accepted by the profession for adults than for children It has been held that since the bones in a child are smaller and not fully developed the operation should be postponed The authors position is that the child should be given the advantage of an immobilizing operation at the earliest possible moment In a case of acute, progressive spinal disease in a child, one often observes excessive hinge motion at the center of the kyphosis accompanying respiratory movement This indicates that the underlying vertebral bodies have disintegrated the respiratory thrust has been concentrated into the area left without the immobilizing support of the intact vertebral bodies and a vicious cycle is set up the greater the mobility the more rapid the destruction, and the greater the destruction the greater the increase in mobility The bodies melt away progressively

It is clear that this process must be checked as soon as possible and it is equally clear that frames and braces cannot be expected to meet such demands—operative treatment is the only solution If a continuous bone graft bridge is inserted at the point of greatest mechanical advantage—in the distal portion of the spinous processes—the minute the sutures are tied the immobility is favorably influenced.

ALBEE BONE GRAFT FIXATION OF THE VERTEBRAE

The detailed steps of the author s technic—the preparation of the graft bed together with the removal of a suitable graft and its implantation are as follows

Preliminary Preparation After ruling out any contraindication to operation the first important step is the marking by lateral roentgenograms of the exact vertebrae involved in the diseased process This is done in every case by placing a small piece of lead at the apex of the kyphosis or if no kyphosis is present, at a point near the area of disease previously determined by x rays A corresponding marker one which will not be removed by later preparation of the skin is placed on the skin surface The authors prefer a small black silk suture inserted into the skin directly under the lead marker A silver nitrate caustic may be used but with this there is a danger of erosion and infection.

On the day previous to operation, or two days before operation, the site of the operation, including the lower left leg, should be carefully prepared by shaving, cleansing with benzine, and painting with tincture of iodine and 70 per cent alcohol. The parts are then wrapped in sterile towels which remain on until the patient is placed on the operating table when they are removed and the parts again painted with tincture of iodine and alcohol

Position In every instance the patient is in the prone position with head overhanging the table and held by a special rest.

Incision This is semilunar in shape, usually six to eight inches in length, beginning well above the site of the lesion, swerving in an arc *slightly to one side of the midline at the level of the diseased vertebrae* and returning to the midline at a point well below the diseased area By having the free edge of this semilunar skin flap away from the site of operation, the engrafted structures are guarded from contamination in the event of skin or suture infection

Exposure After dissecting and reflecting the skin flap the tips of the spinous processes lie directly exposed Hemorrhage, usually slight, is best controlled by compression with towels wrung out of hot saline solution A small amount of serous exudate and blood is considered advantageous to early nourishment of the graft.

Preparation of the Graft Bed With a scalpel the supraspinous ligament is split into halves *longitudinally over the tips of the spinous processes* of the involved vertebrae, as well as one or two healthy ones above and below The interspinous ligaments are treated *likewise Muscular* and ligamentous attachments to the spinous processes must not be otherwise disturbed

With the Albee thin sharp 1½ inch osteotome—its cutting edge parallel with the tips—the spinous processes are split into halves to a depth of from ⅔ to ¾ of an inch or nearly down to the neural arches. *One half of each spinous process* always on the same side is fractured completely at its base and set over a distance varying according to the thickness of the graft which is to be implanted Care must be taken to prevent breaking the remaining spinous process *halves and to preserve* their full leverage action Bleeding should be checked by ligatures or hot saline compresses

The graft bed thus prepared presents a median longitudinal gutter on one side of which are the cut surfaces of the unbroken halves of the spinous processes (with the cut surfaces of the bisecting supraspinous and interspinous ligaments with their osseous attachments undisturbed) and on the other side the cut surfaces of the fractured halves of the spinous processes (with their corresponding bisected ligaments attached) It is to be noted that the muscular and ligamentous attachments are undisturbed save for the splitting fracturing and spreading inci

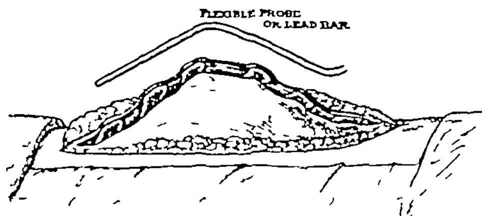


Fig. 113. The flexible probe bent to conform to the spinal kyphosis and used as a pattern in removing the curved graft from the antero-internal surface of the tibia. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

dental to bisection of the spinous processes This leaves the anteroposterior diameter of the spinal column undiminished and unweakened and preserves the full leverage activity of the spinous processes as posterior arms of the vertebral levers

It should be constantly borne in mind that the spine is a composite of a series of levers each one of which has its short (anterior) arm the vertebral body and its long (posterior) arm the spinous process

The length and shape of the required graft is determined by calipers and a flexible probe applied to the gutter bed which is then protected by a hot saline compress tightly packed awaiting the preparation of the graft

Removal of the Graft The patient being in the prone position, the prepared leg is raised from the operating table and flexed to an acute angle with the thigh A skin incision is made along the antero-internal

surface of the tibia This should be long enough to allow a generous exposure of the tibia for the removal of the graft, and so placed that its closure will not bring the skin sutures over the bony cavity produced by removal of the graft. The skin is dissected up from the periosteum

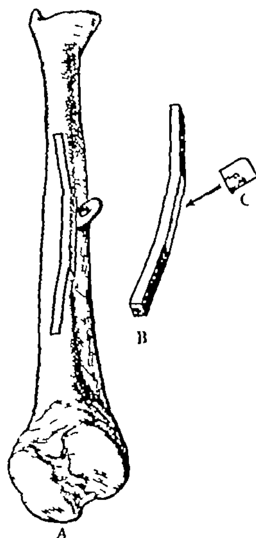


Fig. 114. *A* saw-cuts in the antero-internal surface of the tibia for obtaining a moulded graft *B* a longitudinal view and *C* a cross-section of the same at its strong central portion. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

(but the latter is not disturbed), and the muscles freed from their attachments to the outer side of the tibial crest.

The size and thickness of the graft required depends upon the segment of the spine to be immobilized and the amount of strain to be placed upon the graft. In general such a graft should include the total

thickness of the tibial cortex (periosteum, endosteum, and marrow), and its width should be three or four times this amount

Using the molded probe as a pattern, the required graft is outlined on the periosteum with a scalpel The lower three fourths of the antero-internal surface of the tibia is selected because of its strong, dense cortex

If the graft is to be straight it is best to remove it from the crest so as to obtain the required width If it is to be molded for a moderate kyphosis the central or fulcrum portion of the curved graft should include the crest of the tibia, and from this portion each end should be

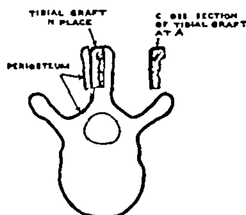


Fig. 115 Method of placing graft so that its marrow surface will contact marrow of intact half of spinous process. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

cut obliquely upward and downward on the antero-internal surface of the bone The advantage of this graft lies in the dense thick cortical tibial crest bone which forms its central portion where the greatest stress will be placed upon it.

Sharply angular kyphosis and those of short duration, particularly in children, are amenable to varying degrees of correction. In molding the graft, its pattern should be that of the gutter bed after moderate correction has been applied by manual pressure on either side over the lateral masses

To obtain the straight graft, the tibial cortex is cut through to the marrow cavity with the motor circular saw following the periosteal outlines of the pattern This includes a saw cut just to the outer side of the tibial crest, and at right angles to the one previously made on the antero-internal surface This cut must be made the whole length of the

graft, if a straight one and if a molded one, only to include the middle or central portion. At either end, beyond this central or crest portion, the graft overlies the marrow cavity, and the saw cuts, therefore, need be made only on the antero-internal surface to free the graft.

The graft is freed at either end by cross cuts made with a very small motor saw It is then loosened and pried out by a thin osteotome introduced into the longitudinal saw cuts Although a thin chisel and a mallet may be used without the motor saw to remove a bone graft the motor saw has very distinct advantages, particularly in the case of very dense, brittle bone in adults where the tibia or the graft might be easily cracked with mallet and chisel Other disadvantages of the latter method are the possibilities of traumatism of the graft, inaccuracy in the molding of it and postoperative pain in the leg

The graft is immediately transferred from the tibia to its spinal bed all unnecessary handling being avoided by using clamps instead of the operator s fingers for its transference

Inlaying the Graft In instances where the graft is straight it is held in place by strong sutures of kangaroo tendon, passed through one-half of the split supraspinous ligament at one side of the gutter, thence up over the graft at its central portion and out through the opposite split half of the supraspinous ligament. After these sutures have been tightened and tied, the two halves of the split supraspinous ligament are thus approximated over the central portion of the graft The extremities of the graft are then secured in like manner The sutures should be passed deeply enough to get a firm hold upon the ligament and close to the spinous processes (either above or just below them) so as to obtain the most intimate contact possible between the graft and the raw surfaces of the bisected spinous processes

In some cases in order that the supraspinous ligament may yield and completely cover the graft, it is advisable to place the sutures in the ligament midway between the spinous processes or at a varying distance to the side of them. This ligament in the lumbar region (particularly in adults) may be so dense and tense as to require incision of the vertebral aponeurosis on either side just external to the line of the sutures to permit of its being drawn together to cover the thick graft.

The graft must, in every instance, be long enough to include the spines of two healthy vertebrae above and two below the diseased area. It must be borne in mind constantly that because of the natural obliquity of the spinous processes in certain regions (particularly the dorsal) the x ray appearance of their tips well below the horizontal planes of their corresponding bodies may mislead the operator into cutting the graft too short to include the requisite number of healthy spines, or of placing it too low in the spine. A satisfactory lateral radiogram should always be

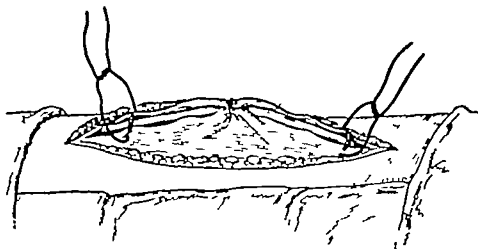


Fig 116 Moulded graft for Pott's disease in place with the kangaroo tendon sutures in process of being inserted. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

obtained as much to confirm the diagnosis as to serve as a guide in inserting the graft. In the 35 years since devising this operation the senior author has seen hundreds of cases where this precaution was not taken, with the result that the graft was either too short or wrongly placed

Before fixing the ends in position their sharp corners are removed by rongeur forceps and the fragments placed about and under the graft ends before the latter are secured with sutures The removal of these bone fragments from the ends of the graft on its posterior edge-surface by means of the rongeur cutter avoids the formation of hygromata from the irritation of the sharp corners as well as gives the graft a roughened surface which helps it to hold better thus preventing its springing backward through the ligaments sutured over it. The fragmented particles furnish added foci for bone proliferation and enhance the amalgama

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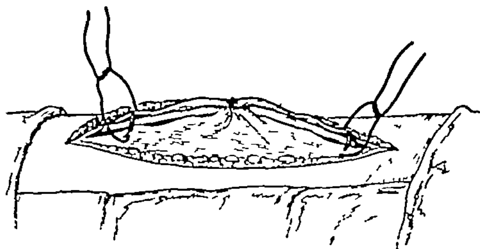


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Fig. 117 Roentgenogram taken ten years after fusion of the spine by bone graft for Pott s disease. Note mechanical advantage of secondary column of bone formed by the bone graft in resisting advancing kyphosis. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

tion of the graft ends and the contacted spinous processes The rest of the graft is then secured with kangaroo tendon sutures placed in the manner just described

If a straight graft with transverse saw cuts made on its marrow surface, two-thirds or three-quarters of the way through its thickness, is to be bent, it should be obtained from the lower two-thirds or three fourths



Fig. 118. Bony ankylosis of lumbo-sacral joint induced by bone graft fusion twenty-one years previously Note maximum hypertrophy of graft at point of greatest stress in accordance with Wolff's law (*From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York*)

of the antero-internal surface of the tibia where the cortex is thick, and may or may not include the crest, as the operator decides If the graft does not include the crest the use of the twin saw hastens its removal and insures its uniform width throughout. If it includes the crest, cuts at right angles to each other on each side of the crest are necessary The graft in the latter case includes two periosteal surfaces, and is therefore more active osteogenetically and stronger mechanically This is called

the bent in graft, and as the saw cuts naturally weaken it the molded graft previously described should be used instead whenever possible

In making the transverse saw cuts to allow the graft to bend (as a carpenter cuts a board to bend it around a curved surface) the graft is held securely by the operator with two strong clamps, one at either end

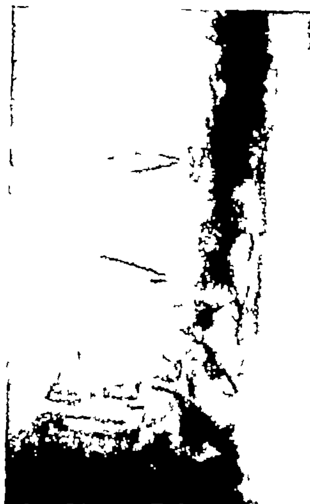


Fig. 119 Excellent result 26 years after spine fusion for Pott s disease of lumbar vertebrae at two foci. Patient is a seaman engaged in the most strenuous type of activity Note absence of deformity-amalgamation in two locations of formerly diseased vertebrae by osseous union and firm incorporation of bone grafts with the trabecular system of the spinous processes. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

An assistant holds the motor firmly on the instrument table with the saw overhanging its edge The current (under the operator s control by means of a foot switch) is turned on The operator presses the graft up from below against the rapidly revolving saw By holding the graft as directed

he can regulate the spacing and depth of the cuts, and can test its flexibility and judge very accurately when he has rendered it sufficiently flexible to conform to its bed and span the deformity, without being obliged to place the graft repeatedly in position to determine this point

The bent in graft is laid in its bed with the medullary surface (scored with saw cuts) downward (anteriorly), the periosteal surface upward, and its edges in contact with the cut surfaces of the gutter side and the split spinous processes In other words the bent in graft is not placed between the split spinous processes edgewise but with its wide diameter laterally

Suturing is performed as for the other types of graft, except that the bent in graft is firmly sutured first at one end and then at the middle, allowing the other end to project freely This free half is slowly bent by consecutive suturing from the central point of the graft outward to its projecting end thus obviating the danger of fracture which might result if it were held bent in place by one embedding suture at each end while the intervening ones were added.

Whether or not fracture occurs in the graft, it is well to reinforce this graft by placing along each of its sides, at the point of maximum curvature, thin strips of cortical bone cut with the motor saw from the tibia where the graft was obtained

As an alternative—and one preferred by the authors for its ease of execution—there is the bundle of reeds, or bent shingle, technic. It should be understood that such bent grafts are used only when a molded graft of sufficient curvature cannot be obtained from the tibia or pelvis

"BENT SHINGLE" TECHNIC OF SPINAL INLAY BONE GRAFT

For cases of sharply angular kyphosis or those of great extent where it is impossible to cut a molded graft of sufficiently angularity from the tibia or the pelvis the authors have devised the following procedure

The graft bed in the spinous processes is prepared as for the other types of graft just described. The leg is given the customary preparation and the incision for the graft is made in the usual manner With the single motor saw two cuts (each about six inches in length) are made in

the antero-internal surface of the tibial cortex—one close to the external, and the other close to the internal limit of the medullary cavity With the same saw, the intervening cortex is now cut into strips, each about 1/16 to ⅛ inch in breadth These strips are released by the small cross-cut saw One of these strips is cut into halves One of these halves is laid, on its flat side, in the spinal gutter at the lower extremity of the kyphosis One of the long thin strips of bone is then placed on top of it, its lower half exactly above the short piece underneath, the remainder projecting Upon this projecting end another long thin strip is laid in similar fashion This procedure is repeated with each of the strips, just as a carpenter shingles a roof Care must always be taken that each succeeding shingle overlays not only the projecting end of the preceding one, but also about one third of the undermost one—in other words, so that there will be three thicknesses of bone strips at each point of junction. When the upper extremity of the kyphosis has been reached the short half piece of bone strip (its other half having been used to start the shingling process) is slid beneath the last two shingles laid.

Sutures of small sized kangaroo tendon or other material, are passed through the spinal ligaments at the points of junction of three shingles" and at such other points as seem to be indicated.

The remainder of the technic and the postoperative treatment are the same as in the Albee spinal inlay operation previously described

Remarks The technic above described is applied to the bone graft implantation into all segments of the spine. The anatomical variations of the spinous processes of the different segments must be borne in mind, as well as the degree of strain and leverage action of the different segments For instance in the cervical or upper thoracic region, the strain placed upon the graft is much less than lower down, from the mid thoracic region to the sacrum. The strain and leverage action of the column as a whole increases materially toward the sacrum so that a graft implanted into the lumbar region will have a greater amount of strain to resist than one at any segment above, not only for this reason but because of the greater flexibility of this segment of the spine In this region the general leverage that will have direct bearing upon the graft includes not only the weight and force applied throughout the entire length of the spinal column above the implanted graft but also the force

of the leverage action from the muscle pull of that portion of the trunk and lower limbs which extends below the graft

ALBEE "BUNDLE OF REEDS" TECHNIC

Parallel strips of bone are taken from the tibia, as in the *bent shingle*

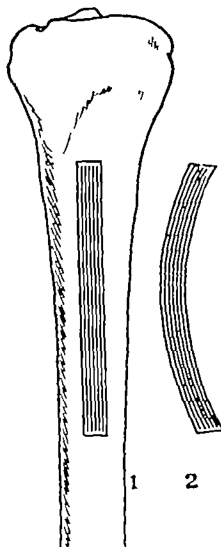


Fig. 120. "Bundle of reeds" technic. Intermediate cuts fall short of transverse saw-cuts so that graft remains intact and greater flexibility is obtained. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton Century Company New York)*

technic except that each graft is long enough to span the entire diseased area of the spine The bundle of thin grafts is easier to bend than the shingle graft, and the authors use this technic in many cases of marked kyphosis where it is possible to obtain strips of sufficient length

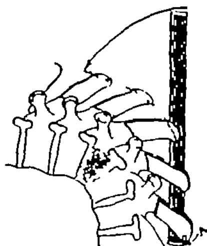


Fig. 121. Flexible graft placed edgewise in spinal gutter (*From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.*)

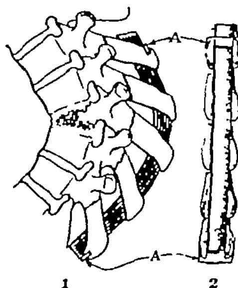


Fig 122. Fixation of "bundle of reeds" graft by bone chips. 1 Lateral view 2. Posterior view Showing the "bundle of reeds" in split spinous processes fixed in place by bone chips at *A*. (*From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company, New York.*)

Closure The skin wound is closed in the usual way and sterile dressings are applied. Thick pads of gauze and cotton, varying in thickness according to the degree of the kyphosis are placed on each side of the

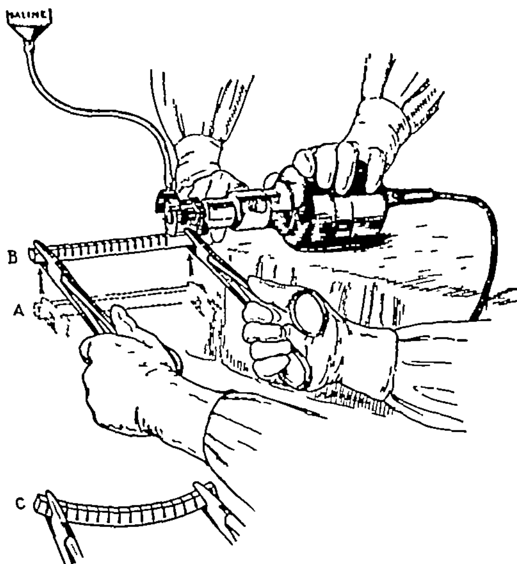


Fig. 123. Method formerly practiced by authors for bending the graft. *A* the manner of holding the graft while making the transverse saw-cuts to increase its flexibility *B* transverse saw-cuts at equal intervals and over three-quarters through the diameter of the graft on its marrow surface. *C* testing for the desired amount of curve in the graft obtained by making the transverse saw-cuts before applying it to the kyphosis of the spine. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

grafted area to prevent pressure sores on the apex of the grafted kyphosis The dressings and pads are then secured in place by broad strips of zinc oxide adhesive plaster It is not safe, even with this dressing to

allow a patient with a prominent kyphosis to lie upon the back Such a patient must be restrained upon the side, or obliquely upon the back during the postoperative recumbent period.

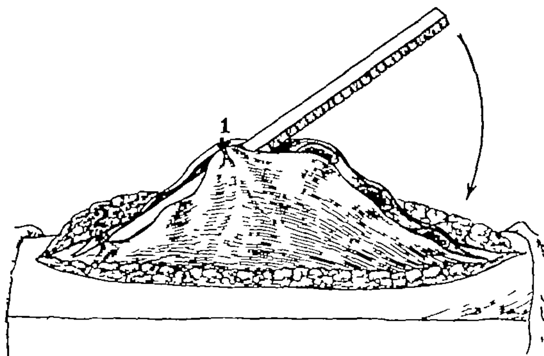


Fig 124. Diagram showing alternate method of molding graft into bed.

POSTOPERATIVE TREATMENT

Immediately following the operation the patient is transferred to the fracture bed and recumbency upon the back is maintained for a minimum of six weeks for an adult and eight weeks for a child, in favorable cases No cast splints or external fixation of any kind is applied except in the case of young children or others whose condition render this necessary Then a towel is pinned about the thorax and fastened to the bed and four broad muslin bandages are attached one end to the towel and the other to the four corners of the mattress This will prevent the child from sitting up or rolling from side to side, and especially from turning while asleep

However if a marked kyphosis is present it is best, in addition to the thick pads already in position over the wound to secure the patient in lateral oblique position to obviate undue pressure on the kyphotic grafted area, and consequent necrosis of the skin flap For these same



Fig. 125 Lateral roentgenogram of a spine of a man twenty two years old, which is illustrative of the extreme degree to which an adult tibial bone graft (*A C B*) can be bent. *C* indicates the saw-cuts in the marrow side of the graft. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

reasons, it is unwise to employ the Bradford Frame with its rigid canvas covering, or the plaster of paris jacket immediately following the operation

During the entire convalescence, these patients should be under a careful general regime of bodily rest, wholesome feeding sunlight, and fresh air Adults although they often enjoy complete relief from symptoms and repeated x rays show arrest of the active disease should refrain from work for at least six months or more following the operation and children should be encouraged to live an out-of-door life—with daily rest periods and exercise subject to supervision and restraint

The authors recommend external supports only when a patient is obliged to be moved from his bed too early or when there is a marked kyphosis necessitating the insertion of a graft with transverse saw cuts, or one bent at a very acute angle or whenever the symptoms persist In such exceptional cases, a plaster jacket or spinal brace is applied and worn for a few months just as in other cases where either of these is indicated

REASONS FOR FAILURE OF THE GRAFT TECHNIC

Recently the senior author had the privilege of reviewing roentgenograms of a series of bone grafted cases at a large orthopedic hospital which had been written up and published as indicating that the graft had brought no higher ratio of success than in cases not operated upon As a result of careful x ray study, it was found that the majority of the failures could be attributed to the fact that the diseased area had not been carefully marked before operation resulting in one of the following fatal errors

1 Graft too short. The graft should always include at least two vertebrae above and below the diseased area

2 Graft inaccurately placed, not including the diseased vertebrae In some instances the graft was longer than necessary but still did not include the diseased area.

3 Graft too weak and small In such cases the graft broke and as in other instances, of course had no beneficial influence This was true in 70 per cent of all the cases in this particular series

GIRDLESTONE'S TECHNIC OF THE COMBINED LAMINECTOMY AND GRAFT OPERATION

The incision is slightly to the left side so as to keep the scar away from the spinous processes, and in order that the motor saw may be used un

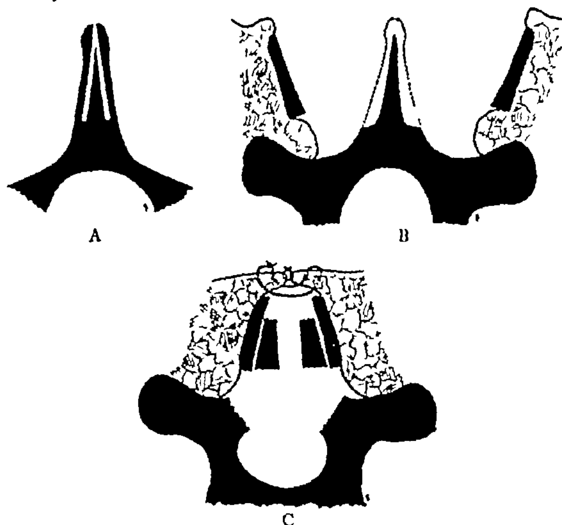


Fig. 126. Girdlestone's technic. *A* motor-saw cuts into a spinous process. *B* state of affairs after reflection of osteoperiosteal flaps in the area of the laminectomy *C* grafts bridging defect left by laminectomy with their lateral osteogenetic beds. *(By courtesy of Prof G R. Girdlestone) (From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

hampered by retractors on the surgeon's side The skin and subcutaneous tissue are lifted from the deep fascia and reflected away from the surgeon beyond the line of spinous processes the skin edges are closely and smoothly covered with fine towels

Then an incision is made on to the apex of each spinous process and carried by a dip of the point of the knife through the interspinous liga

ments over an area covering the three spines of the laminectomy area, two spines above and two below As the line of processes is often deranged by caries, and as it is best to make the incision run exactly over the apex of each process, it is helpful to define each process as the incision reaches it by gripping it between the points of a pair of dissecting forceps held in the left hand. The motor saw is then taken and two inci

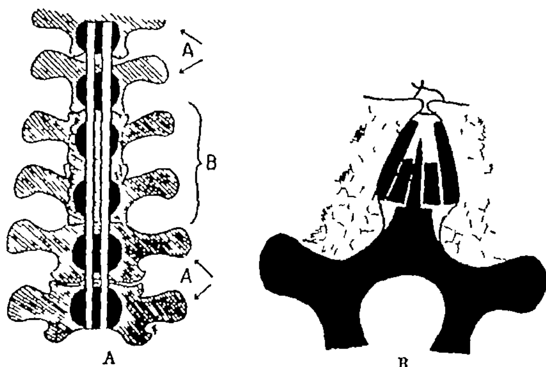


Fig. 127 *A* Diagrammatic coronal section of spinous processes and graft, with vertebrae and area of laminectomy indicated *A* grafts well supported on spines *B* area of laminectomy *B, showing grafts as supported on spines above and below* area of laminectomy *(By courtesy of Prof G R. Girdlestone) (From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company, New York.)*

sions are made into each spinous process forward and slightly outward to the right and to the left They start in the knife cut and separate a thick flake of bone from the spinous process on each side. When each process has been dealt with in this way the saw is laid aside and an osteotome 1½ inches wide, is used to complete the separation of the lateral flakes of bone from the central part of each spinous process and then to carry these flakes outward, together with the periosteum of the bases of the spines and laminae (An osteotome very broad so that it cannot possibly get between the laminae and so sharp that it can be used

gently without disturbing the carious centra, is recommended) Each time the osteotome travels outward, the space between it and the spinous process is packed with gauze so that by the time the upper end is reached there is a thick packing all the way up that side The other side is treated in the same way It should be said that the laminae are only fully exposed where they are to be removed In the case of the two spines above and below, the displacement of the flake of bone and periosteum does not go beyond the base of the spinous process

The laminectomy is then performed It is essential to make the lami nectomy opening of full width and long enough to relieve all the pressure present or at all likely to occur In the authors experience, it has never been necessary to remove more than three laminae for Pott s paraplegia The dura is not opened but rather, the surgeon seeks around it, and sometimes evacuates a mass of debris from the side of the theca.

Next comes the graft The length and shape of the grafts required are recorded by bending a probe, and two grafts about ⅜ of an inch wide are cut from the tibia. These can generally be straight. If so, they are put in with the periosteal surface deep, that is with the smooth limiting membrane turned toward the theca If the spine is straight or only moderately kyphotic, this gives plenty of clearance at the site of the lesion because the grafts are carried fairly high up on the spinous processes above and below If, on the other hand, there is much angular curvature, one of two methods must be used

1 *Shaped grafts,* to fit the angulation. This means using the broadest part of the tibia and not sparing the crest

2 *Flexible grafts* (bent in or bundle-of reeds technic) When the grafts are firmly in place, and one has made certain that there is plenty of space between their deep surface and the theca the edges of the supra spinous ligament, carrying with them the lateral flakes of bone from each spinous process are sewn together over the grafts Just previous to this if there are one or more prominent spinous processes they are nipped across with bone-cutting forceps and bent under the suture line This makes for comfort and safeguards the skin from pressure The operation is completed by suture of the skin of the back and the leg *

* G R. Girdlestone, Brit. J Surg., July 1931 19 121 141

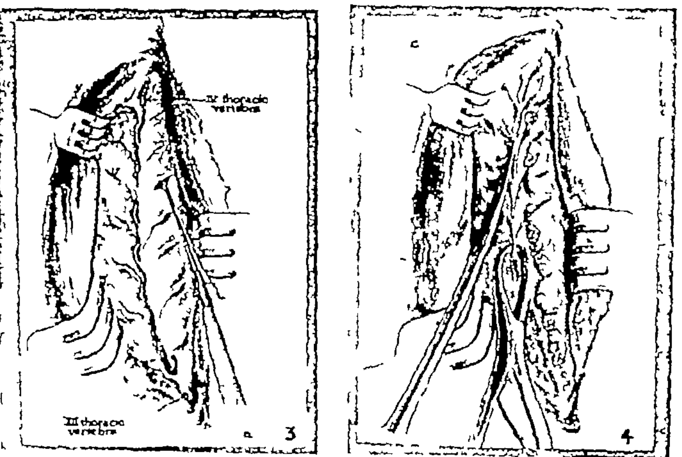


Fig. 128. Hibb s technic, 3, reaming out of articulations. 4, Hibb s technic, production of bone bridges by operative destruction of laminae and spinous processes. (*From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.*)

HIBBS OPERATION

Hibbs conceived the idea of removing the periosteal structures from the spinous processes, dividing the latter at their bases, and so placing them longitudinally in the interspinous spaces that their ends touch the bases from which the processes have been removed This operation therefore, attempts fusion at five different points—the laminae, the articular processes of the facets on each side, and the spine in the midline

Technic A longitudinal incision is made directly over the spinous processes, through the skin supraspinous ligament, and periosteum to the tips of the spinous processes The periosteum is split over both the upper and lower borders of the spinous processes and the laminae, and stripped back from them to the bases of the transverse processes The spinous processes are then transposed and partially fractured so that they may contact the fresh bone the base of each with its own base, and the tip with the base of the one next below The adjacent edges of the laminae being absolutely free from periosteum a small piece of bone is elevated from the edge of the laminae and placed across the space between them, its free end in contact with the bare bone of the lamina next below it. The lateral walls of periosteum and the split supraspinous ligament are brought together over these processes by interrupted chromic catgut sutures The skin wound is closed by silk and a steel brace is applied with the space between the uprights of the brace increased somewhat at the site of the wound so as not to exert pressure upon it In some cases the gaps in the periosteum removed from the spinous processes and laminae have been closed by suture thus establishing a continuous periosteal wall immediately

Hibbs advises absolute rest in bed for from eight to ten weeks sitting up for the following four weeks and walking at the end of 12 weeks The brace is continued for another month, when it is removed for a part of each day until gradually it is left off entirely In the case of children under five years of age the brace should be worn for six months

ALBEE AND HIBBS COMBINATION METHOD

Steindler and others have at times used a combination of the Albee and Hibbs technics with slight variations The principle of the opera

tion is a subperiosteal dissection of the spinous processes from the *laminae down to the pedicles and a gouging* out of the intervertebral articulations, particularly in cases involving the lumbar spine In the dorsal spine, some prefer to omit this latter procedure Steindler removes *two grafts from the tibia, of* the desired length and size, and places them over and in contact with the denuded laminae and spinous processes. These grafts are then held in place with catgut sutures

YOUNG'S OSTEOPERIOSTEAL METHOD

This procedure includes exposure of the spinous processes of the laminae subperiosteally and reflection of the soft tissues laterally care being taken to remove every vestige of the ligaments from the spinous processes Two osteoperiosteal grafts of the desired length are taken from the tibia and placed so that their raw surfaces are in perfect contact with each lamina and base of the exposed spinous processes

If there is a marked kyphosis in the thoracic region, Young advises the removal of the tips of the spinous processes This is done to decrease the visible deformity

MECHANICAL OR CONSERVATIVE TREATMENT

Pott s disease is a distinctly surgical affection and operative treatment should, when possible, be *given precedence* over all therapeutic measures It cannot be expected that purely external means will be sufficient to accomplish the complete immobilization that is so necessary nor aid in the *revascularization of the diseased vertebral bodies*—the two important factors in the treatment of tuberculosis of the spine

Mechanical Treatment This should occupy a minor position and should be employed only

1 When the patient refuses to submit to an operation Then a conservative attempt to immobilize the spine is the only alternative.

2 As a postoperative adjunct, in some cases of marked kyphosis and in other special cases where indicated.

3 In cases that are not good surgical risks. To be used until the general condition of the patient has improved under special care

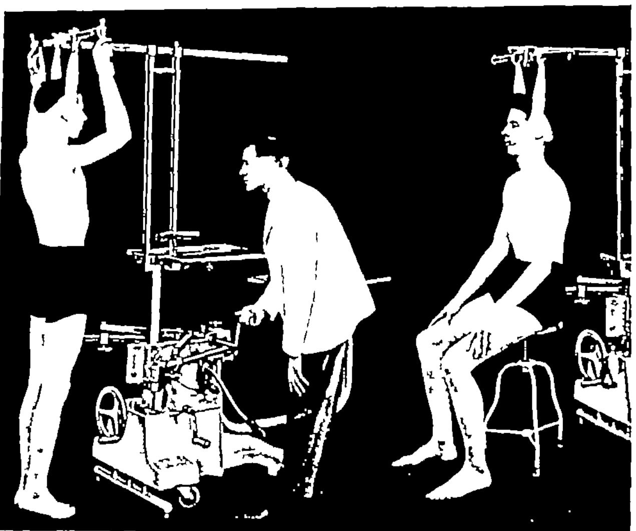


Fig. 129 Sayre suspension by crank-controlled crane incorporated in Albee-Comper Fracture Table. Instead of rope and pulleys usually associated with this posture and the tendency of the rope to slip on its fastening, Sayre Suspension is managed by a crane incorporated in the design of the Albee-Comper Fracture Table. This crane will support the weight of two persons with the casters locked by the floor lock, and is elevated simply by turn of the crank absolute precision without any slippage is therefore assured and the amount of vertical traction is under accurate and easy control of the surgeon. The arms, as shown, may be slung from the overhead frame conveniently out of the way when the plaster jacket is applied. If the patient is unusually tall, further height is obtained by the hydraulic lift control and, it often being desirable to seat the patient, the crane may be cranked right down as illustrated.

4 As a temporary measure

(*a*) In cases of general infection and bacteriemia.

(*b*) In cases of exanthema and other complications

(*c*) Where there is an infected field of operation

Mechanical treatment is administered in three ways, according to the progress of the patient

1 Recumbent—*during the stage of acute symptoms*

2 Ambulatory—after the surgeon feels that symptoms have subsided to the point that the patient may be allowed out of bed with support.

3 Convalescent—when the gradual removal of support under supervision is indicated.

Recumbent Treatment This type of treatment removes the superincumbent body weight from the diseased vertebral bodies, with relief from acute symptoms in many cases Such treatment is indicated in all cases of postoperative fixation, or when the patient refuses operation and as a temporary method of relieving acute symptoms, when a temporary complication preventing operation exists.

The Bradford Whitman Frame This is an effective and convenient support and consists of a rectangular frame made from gas pipe, 1½ feet longer than the patient, and of a width equal to the intermaxillary distance The frame is covered with heavy canvas, drawn taut by means of corset laces on its undersurface The canvas may be made in two sections with an interval between to allow for the bedpan To prevent pressure and possible excoriation it is advisable to sew two felt pads about seven inches long of sufficient width, and about ¾ inch thick to the canvas where the tip of the kyphosis comes into contact with the canvas The patient is held in place by a front piece or apron secured to the sides of the frame by straps and buckles As soon as the patient becomes accustomed to the restraint, the hyperextension of the spine is increased from time to time by the bending of the frame upward beneath the kyphosis This tends to separate the vertebral bodies relieving them from pressure partially for the time being

In the case of children, the clothing should be made large enough to include the frame, thus avoiding the necessity of removal from the frame for change of outside clothing

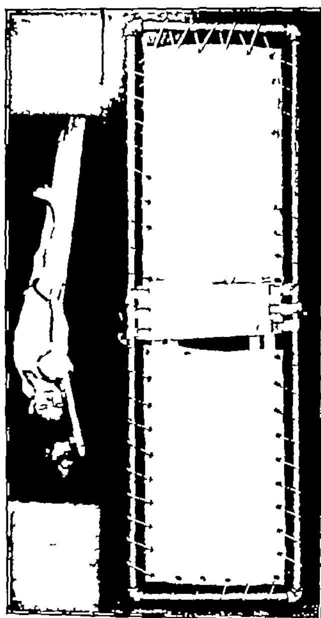


Fig. 130. Bradford frame, and hyperextension Bradford frame with Carrell attachments. (*From Operative Orthopedics by W C Campbell C.V Mosby Co., 1939*)

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Fig. 130. Bradford frame and hyperextension Bradford frame with Carrell attachments. (*From Operative Orthopedics by W C Campbell C.V Mosby Co., 1939*)

The patient should be kept upon the frame constantly, except for a once-daily removal to permit inspection for excoriations, alcohol rub and general care The frame should be replaced as soon as possible and great care should be taken during all handling to make sure the patient never assumes a vertical position

When the disease is located in the cervical upper dorsal or last lumbar vertebra, special supplementary traction appliances must be used In very acute cases it is sometimes impossible to relieve the symptoms completely with the frame and a light plaster jacket or brace may be necessary as well

Remarks on Frame Treatment Pain and discomfort often disappear within a few days after the patient is secured to the frame If the conservative treatment is to be followed, the treatment of choice in all acute cases is the horizontal frame However as this is not complete immobilization, only the best mechanical procedure possible, sooner or later ambulatory fixation becomes necessary

Duration Frame treatment may last for nine months or it may last for from eight to ten years the period of recumbency for disease in the upper dorsal region, being the longest Indications for the discontinuance of a frame in favor of ambulatory treatment are the relief of all symptoms and the apparent arrest of all local disease, as indicated by physical findings and x rays, and by the increased freedom of motion and restlessness when removed from the frame for routine care. In all cases recumbency should be continued until

1 All pain disappears.
2 Deformity is stationary or absent.
3 Evening temperature fails to increase for several months.
4 Body weight increases
5 X rays show definite formation of new bone.

Ambulatory Treatment When in the opinion of the surgeon the patient is considered able to get about, the spinal column must be supported by either a brace or a plaster jacket, with the addition of some type of head support, for diseases above the ninth dorsal vertebra The plaster jacket is recommended for children, as it is not so easily thrown out of adjustment as the brace which is better suited to adults Ambu

latory treatment should be continued for approximately two years in most cases

Essentials of Efficient Spinal Supports

1 A fixed point—preferably at the pelvis—from which constant pressure may be exerted.

2. Construction permitting the exertion of pressure along the transverse processes on each side, especially in the region of the kyphosis

3 Nothing to compress the lateral chest walls

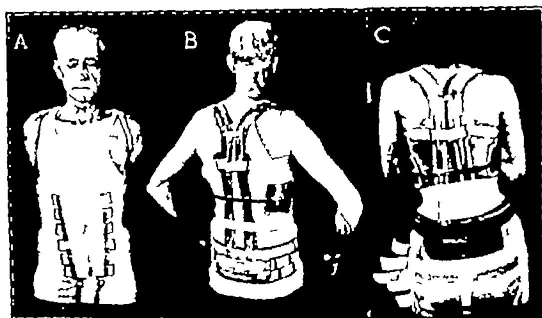


Fig. 131. *A* and *B*, modified long Taylor spine brace. *C* Long Taylor spine brace with sacroiliac attachments.

4 Construction to produce compensatory pressure on the upper portion of the anterior chest wall, pubic and pelvic regions

5 Extension of support in front and above the shoulders if the disease is located between the eighth and tenth dorsal vertebrae.

6 Inclusion of the head in the support if the disease is above the ninth dorsal vertebra.

Plaster of Paris Jacket This is a simple splint of the whole spine and only partially fixes the individual segments It can be expected only to hold the spine in general alignment Its efficiency depends upon accurate and smooth application over the body irregularities and upon its leverage above and below the diseased area

The skin should be prepared for such a jacket by first bathing with alcohol and dusting with talcum powder, and then by applying a seamless jersey shirt or stockinet with sufficient length to allow for its being turned up to form an outer cover for the jacket

The Albee-Comper Table is best used, as illustrated in Figure 129

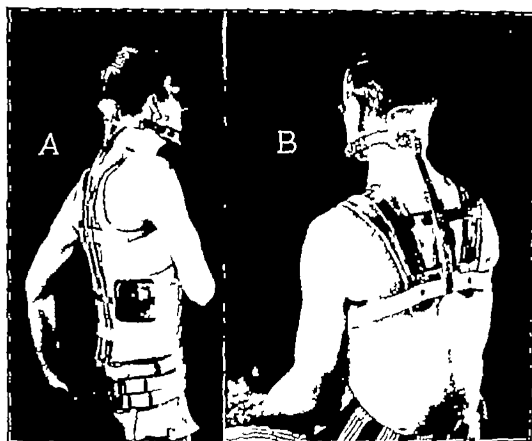


Fig. 132. *A* Long Taylor spine brace with attachment for support of cervical spine. *B* cervical spine brace chin piece removable. *(From Operative Orthopedics by Willis C Campbell C. V Mosby Co., 1939)*

page 209 to apply traction to the head, or if the table is not available, a Calot or Sayre suspension apparatus is adjusted about the head with the patient in a standing position Sufficient traction should be applied to lift the heels from the floor The anterior superior spine, the crests of the ilium and the sternum should be protected by padding and the spinous processes of the kyphosis by a strip of felt on either side to prevent excoriation, and to permit the application of greater pressure

and fixation at the diseased area. In adolescent and adult females the breasts should be protected with cotton

The patient is held carefully in position by assistants, to prevent swaying, and the plaster bandages are applied smoothly The jacket is made of uniform thickness, and should extend above to the sternal notch and below to include the superior iliac crests, allowance being made for trimming Before the plaster sets it is molded to increase its leverage, and trimmed to allow motion of the shoulders and flexion of the thighs However, one or both thighs may be included for acute and painful disease low down or for psoas spasm If the disease is above the ninth dorsal vertebra, the head should be included in the jacket, to lengthen the leverage above the point of disease and to aid in holding the upper portion of the spine in hyperextension

Taylor Spine Brace This consists of two ½ inch parallel steel uprights gauge 8 to 12 one on each side of the spinous processes extending from the buttocks to the seventh cervical vertebra, with pressure pads adjusted to the undersurface of the uprights These permit greater pressure for fixation and correction of the deformity at what is the fulcrum of the brace lever when the upper and lower ends are fixed to the shoulders and pelvis To the lower ends of these uprights is fastened a pelvic band of steel reaching from one iliac spine to the other Opposite the second dorsal vertebra two shoulder pieces of lighter metal extend over the shoulders to about the middle of the clavicles which are padded, and from their ends a strap is passed under each arm and fastened to the upright at about the level of the angle of the scapula. Additional fixation may be obtained by applying an apron to cover the abdomen and securing it in place with buckles and straps

Treatment of Complications

The two chief complications of tuberculosis of the spine are

1 Ichor pocket or abscess formations
2 Paralysis

ICHOR POCKET OR ABSCESS FORMATIONS

This is the commonest complication of tuberculosis of the bone The term *ichor pocket* is applied to the primary circumscribed collection of

tuberculosis detritus formed from the disintegration of bone and fat tissue, plus granulation exudate It is felt that this term is the more accurate, and the word *abscess* is used only when secondary infection of this ichorous material has occurred

Conservative Treatment It should be remembered that, as a rule a collection of tuberculosis ichor usually causes no symptoms even when

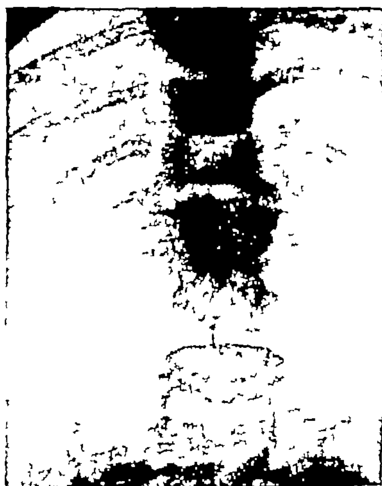


Fig. 133. Old tuberculous abscess with calcareous deposit, complicating Pott s disease of spine.

forming beneath the skin. If the ichor pocket is left alone it frequently will be absorbed, provided its origin, the bone or joint lesion is controlled by appropriate treatment. Therefore as a general rule the ichor pocket should be left alone unless its size demands relief

Operative Treatment This consists of

1 Aspiration

2 Incision

Aspiration is the operation of choice whenever operative interference is required Indications for such interference are

1 Discomfort from size and tension
2 Mechanical interference with the function of locomotion
3 Evidence of pressure necrosis and thinning of the walls with danger of sinus formation
4 Evidence of secondary infection with inflammation and fever

Rules to be Observed When an ichor pocket demands operative interference the following rules should be observed carefully

1 Recumbency and gravitation prior to operation.
2 Rigid asepsis
3 No instrument introduced into the ichor pocket.
4 Avoidance of injury to the granulations lining the cavity, to prevent postoperative hematoma, a more favorable culture medium for bacteria than the innocent tubercular ichor Expression of the contents of the pocket to be made gently
5 Suture of the incision, carefully in layers using absorbable material
6. Application of a large, even compress to prevent reaccumulation of ichor or formation of blood clots
7 Incision through the thick part of the pocket wall (never through the thin part)—long enough to allow fibrous clots to be expressed.
8 Recumbency to be insisted upon for two weeks after incision, to prevent gravitation from causing the wound to break down
9 Heliotherapy after operation whenever possible, to aid in the granulation.
10 When the ichor pocket points in two localities drainage of the one on the higher horizontal plane, to avoid pressure on the sutures and danger of wound necrosis from gravitation of the ichor

Aspiration The patient should be required to remain in the recumbent position to allow the ichorous material to return to its point of origin A thick portion of the wall should be selected and the needle introduced gently and obliquely The obliquity of the needle lessens the danger of sinus formation in the needle tract

Incision The authors recommend incision only when it is necessary for the removal of fibrous clots impossible to remove by aspiration. The danger of secondary infection following incision is greater than that following aspiration, despite the utmost care in the technic of operation and subsequent dressings.

SPECIAL SPINAL ICHOR POCKETS

For vertebral ichor pockets pointing in the following localities special treatment is required

1 Retropharyngeal or prevertebral cervical ichor pocket
2 Supraclavicular ichor pocket.
3 Prevertebral thoracic ichor pocket.
  (*a*) Rib resection
  (*b*) Costotransversectomy
4 Lumbar ichor pocket
  (*a*) Subcostal ichor pocket
  (*b*) Ichor pocket in Petit s triangle
5 Iliac ichor pocket

Retropharyngeal or Prevertebral Cervical Ichor Pocket (Cold Abscess) Incision should never be made through the mouth as the danger of infection is too great The incision should follow the upper third of the posterior border of the sternomastoid muscle care being taken to avoid the spinal accessory nerve emerging from the posterior border of the muscle The muscle is retracted forward exposing the splenius and levator anguli scapulae. If freer exposure is necessary the muscle is partially severed near the mastoid Since the ichor pocket lies in front of the transverse processes, access to it is gained by passing the finger inward along their anterior surfaces displacing forward the jugular vein which lies in front of the pocket

If the ichor pocket extends across the neck to the opposite side, a second opening should be made behind the opposite sternomastoid

These cases should be watched carefully as edema of the glottis occasionally occurs

If dyspnea and dysphagia are urgent symptoms an incision may be made through the mouth The head is allowed to hang well over the

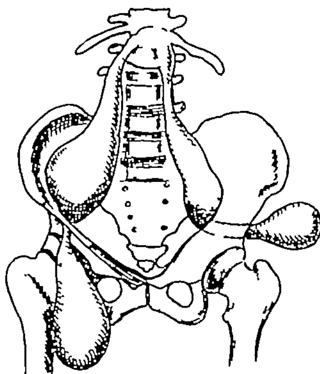


Fig. 134. Disease of the lumbar spine with old abscesses (ichor pockets) gravitating downward under Poupart's ligament on the right and posteriorly through the great sciatic notch.

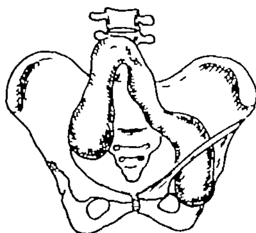


Fig. 135 Psoas abscesses (ichor pockets) originating from lumbar Pott's disease and gravitating downward in the psoas muscle sheaths.

edge of the table (to avoid inspiration of pus) and the jaws are held apart with a mouth gag After opening the ichor pocket, the patient is quickly turned upon his face and kept in this position until the ichor pocket has been completely evacuated. It is advisable to use an antiseptic mouthwash freely after this procedure

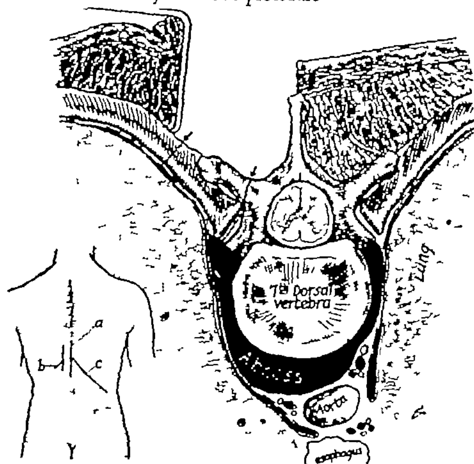


Fig. 136. Costotransversectomy for drainage of tuberculous abscess of dorsal spine. *A* Midline incision. *B* Bickham incision. *C* Kochen incision. *(From Operative Orthopedics by W C Campbell—C. V Mosby Co., 1939)*

Supraclavicular Ichor Pocket (Cold Abscess) In disease of the middle cervical vertebrae, tuberculous ichor passes between the trapezius and sternomastoid muscles and points in the posterior triangle of the neck, above the clavicle Incision should correspond with the lower two-thirds of the posterior border of the sternomastoid muscle care being taken to avoid the special accessory nerve The sternomastoid is retracted inward until the outer edge of the scalenus anticus is in view The interval between the scalenus and longus colli muscles is enlarged with fingers forceps or scissors to evacuate the ichor pocket

Prevertebral Thoracic Ichor Pocket (Cold Abscess) A collection of tuberculous ichor in this location, between the mediastinal pleura and the vertebral bodies, usually presents no objective signs, or subjective symptoms. Occasionally, pressure symptoms on the esophagus trachea left recurrent laryngeal nerve, or the spinal cord demand operative intervention Relief is obtained by one of the following procedures

Rib Resection With the patient in the semiprone position, healthy side downward, an incision is made parallel with the spinous processes of the affected vertebrae, about 1½ inches from the midline, exposing the articulations of the ribs and transverse processes The periosteum is divided and elevated over the posterior surface of one or two ribs These in turn are divided and one or two inches removed from them. The anterior costal periosteum is then incised and the dissection is carried inward and forward along the anterior surface of the transverse processes and in front of the vertebral body to open the ichor pocket

The disadvantages of this operation are the inaccessibility of the lesion, the imperfect drainage obtainable, and the danger of injuring the pleura

Costotransversectomy (Costotransverse Excision) A straight vertical incision is made close to the spine, and the soft tissues separated outward as far as the tubercle of the rib The transverse process of the affected vertebra is first resected, then the head and neck of the rib The finger is introduced the pleura is stripped from the side of the vertebra, and the ichor pocket is penetrated

Instead of a vertical incision, Kocher begins at the most prominent spine and follows the rib to be resected downward and outward

Bickham varies the foregoing technic by using a four inch vertebral incision one-half inch from the midline the center of the incision being over the affected vertebra. He then carries a second incision parallel with the course of the rib to be resected from the center of the first incision downward and laterally Thereafter his technic follows that just described

Lumbar Ichor Pocket (Cold Abscess) Ichor pockets from tuberculous lumbar vertebrae appear in the loin and usually point either between the erector spinae muscles and the last rib or above the iliac crest in Petit's triangle.

Subcostal Ichor Pocket (Cold Abscess) For an ichor pocket in this locality the incision is made along the lower border of the last rib from the outer edge of the erector spinae The latissimus dorsi and serratus posticus inferior are divided, and (at a deeper level) *the outer fibers of* the quadratus lumborum and the middle layer of the lumbar fascia. After evacuation, the wound is closed at once.

Ichor Pocket (Cold Abscess) in Petit s Triangle The ichor pocket of this type extends into the sheath of the quadratus lumborum, pierces the lumbar fascia, and points above the iliac crest An oblique incision is made downward and outward exposing Petit s triangle Such an ichor pocket usually lies in front and to the outer side of the transverse processes of the fourth and fifth lumbar vertebrae.

Iliac Ichor Pocket (Cold Abscess) An incision is made parallel with and about one inch above Poupart s ligament, and of a length commensurate with the size of the ichor pocket The fibers of the external oblique and transversalis are split, and after dissection close to the anterior superior iliac spine, the transversalis fascia is exposed near its junction with the iliac fascia, and behind the iliac fascia the ichor pocket If the pocket is prolonged downward into the thigh, it may be necessary to make a second incision just below the anterior superior iliac spine, and along the outer border *of the sartorius which is retracted and the pocket entered* through the fascia over the iliopsoas internal to the tendon of the rectus femoris The point of election however should be the less dependnt location, near the anterior superior iliac spine All incisions should be carefully closed.

Treatment of Sinuses Tuberculous sinuses often appear due to the spontaneous rupture of an ichor pocket However they are more frequently a sequel to ill advised incision followed by drainage *tampons* There are no symptoms directly referable to sinuses but they serve to continue the secondary infection and demand treatment on that account They may be prevented by guarding against secondary infection of the ichor pockets and by aspiration before the thinning of the abscess wall and spontaneous rupture.

Such sinuses are very difficult to cure because of their tortuosity and the consequent impossibility of excision together with the inability to obtain primary closure The authors feel that the treatment of these sinuses

should be palliative The general condition of the patient should be main tained at its highest level by means of repeated transfusions The treat ment of choice is the use of autogenous bacteriophage, instilled into the ramifications of the sinuses by means of catheters, in conjunction with infrequent dressings

PARALYSIS

Paralysis due to tuberculosis of the spine is merely a symptom and not an independent affection The treatment therefore is treatment of the condition producing it

The patient should be placed in absolute recumbency with the spine in hyperextension on a Bradford Whitman Frame This is especially im portant if the case is an early one and the deformity remediable. While in this recumbent position, trophic disturbances in the form of bedsores must be carefully guarded against and any deformities arising from muscular contractures should be treated by traction or other appropriate measures.

The authors prefer immediate bone graft fixation of the diseased por tion of the spine as the best treatment for this complication (The proce dure of the bone graft operation has been described previously in this chapter)

Laminectomy Removal of portions of the laminae has been tried for many years as a means of relieving pressure on the spinal cord due to tuberculosis exudate However the results following this procedure have been very unsatisfactory and the mortality high, as the posterior part of the spinal cord is exposed rather than the site of the disease, and removal of the laminae further impairs the already weakened osseous structure of the spine. The weakening caused by the laminectomy may contribute to a relapse of the tuberculous osteitis It is more advisable to perform a hemilaminectomy and insert a bone graft into the spinous processes at the same time. Laminectomy is rarely indicated except when the lesion has been complicated by trauma sufficient to bring pressure upon the spinal cord from fracture

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CHAPTER VII

Static Deformities of the Spine

Scoliosis

Scoliosis is a lateral deviation of the spine, with rotation of several or all of the vertebrae away from the sagittal (anteroposterior) plane. This is one of the most common of deformities ranking next to bowlegs in frequency according to Whitman. More than 50 per cent of the cases appear between the ages of 7 and 14 and heredity is unquestionably a factor in a certain percentage

For purposes of description and organization of treatment, scoliosis is here classified in two ways

1 *According to etiology—although this classification is bound to be* somewhat imperfect as our knowledge of the etiology of scoliosis is *meager Kleinberg figures that probably between 80 per cent and 85 per* cent of such cases fall within the idiopathic group

2 *According to clinical types, the level and shapes of the curvatures*

CLASSIFICATION BY ETIOLOGY

Congenital Scoliosis Congenital anomalies of the spine are quite common, particularly numerical variations in its constituent parts, as unilateral sacralization of the fifth lumbar vertebra the reduction or in crease in the number of vertebrae a cervical rib on one side super numerary half vertebrae fused vertebrae congenital elevation of the scapula (Sprengel s deformity), etc. *It is rare for a child to be born* scoliotic without several bony anomalies The usual behavior of congeni tal scoliosis is *a latent bony anomaly at birth—without spinal deformity—* the clinical picture appearing at a subsequent date

Acquired Scoliosis 1 *Idiopathic or Constitutional Forms.* This group constitutes the vast majority of all scoliotics—probably 80 to 85 per cent

Such scoliosis occurs in children in their teens and is most commonly seen in those of overgrown stature The condition is often associated with lack of spinal resistance, and is usually accompanied by relaxation of other joints causing flat feet or genu valgum Muscular tension is also defective, and the child is often anemic, weak, and apathetic Rapidity of



Fig. 137 Photograph and roentgenogram showing habitual scoliosis with a spontaneous compensation of a thoracic curve of 55 degrees by a lumbar curve of 57 degrees. Compensation holding after four years. *(From Journal Bone and Joint Surg., Jan. 1941)*

growth and the changes incident to puberty, outdistance the development of the musculo-lingamentous apparatus. It is difficult to determine which force predominates since muscular and skeletal deficiency are interdependent.

2. Forms Caused by Excessive Malleability of the Bones If a child has rickets the usual method of carrying infants on the flexed forearm, thereby tilting the pelvis may contribute to the production of a total postural curvature the primary deformity appearing as an anteroposterior

curvature later a lateral curve, and finally developing into an organic curve When such a curvature is fully developed, it includes lumbodorsal or marked lumbar kyphotic scoliosis, high cervicodorsal curves and multiple curvature with marked deformity of the thorax

The generalized kyphosis similar to arthritis deformans precedes the lateral curvature, and when it occurs it is severe and intractable. Scoliosis may also follow dislocation of the vertebrae or injury to the epiphyseal cartilages

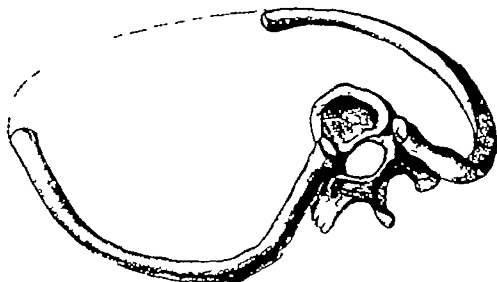


Fig. 138. Deformity of the thorax in scoliosis. *(Hoffa.)*

Other forms of bone softening of the vertebrae which may lead to scoliosis are osteomalacia osteitis deformans tuberculosis syphilis and malignant disease.

3 Occupational Forms In certain occupations a scoliosis may develop through long continued maintenance of a faulty position or habit In this form there is often a mental as well as a physical basis—the sense of balance or equilibrium may be faulty Hod-carriers, school children, joiners and nursemaids are among those prone to such curvature

4 Compensatory Curvature of the Spine This is a frequent form caused by the static obliquity of the pelvis. The underlying cause of such obliquity is an inequality of the lower extremities and the convexity of the curve is usually toward the shorter limb although variations may occur However pelvic obliquity is not always accompanied by scoliosis

if the tone of the spinal muscles is good, and the sense of upright position is not defective The factor of flat feet in the production of scoliosis is not clinically important.

5 Type Caused by Unequal Hearing Torsion of the head resulting from unequal hearing may react upon the spinal column

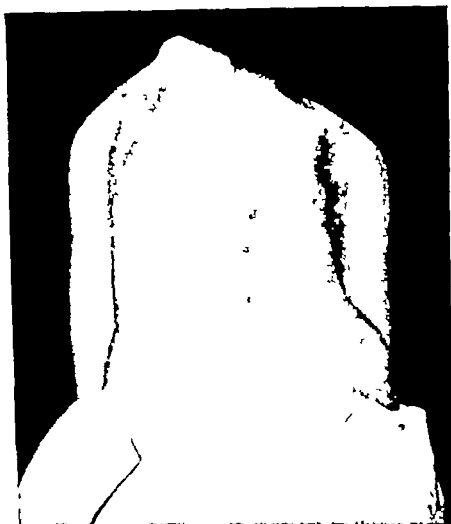


Fig. 139 Keel-shaped projection of left ribs due to rotation unmasked by bending. (Taylor)

6 Type Caused by Unequal Vision. Especially in children, unequal vision is an etiological factor

7 Type Caused by Loss of an Arm. An asymmetrical posture of the trunk caused by the loss of an arm may cause a lateral curvature

8 Neurological Affections Unilateral paralysis or weakness of the intrinsic muscles of the back or of those which normally maintain its

equilibrium, are common causes of scoliosis The following nervous disorders are factors in this respect

(*a*) Anterior Poliomyelitis This produces scoliosis in the following ways by paralysis of one arm by the shortening of one leg, by unevenly distributed paralysis of the trunk muscles and by the most important factor of causing paralysis of the abdominal muscles and intrinsic spinal muscles

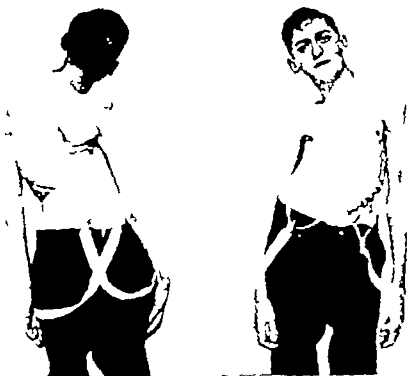


Fig. 140. Collapse of right lung and secondary scoliosis following empyema at the age of five. Portions of two ribs were excised the opening never closed and after 18 years is still discharging. Patient is now 23. (Taylor)

(*b*) Multiple Neuritis.
(*c*) Progressive Muscular Atrophy
(*d*) Spastic Paralysis
(*e*) Tabes Dorsalis
(*f*) Syringomyelia
(*g*) Friedreich s Ataxia
(*h*) Tumor of Cord and Meninges
(*i*) Sciatica.

9 Diseases of the Chest As a result of the cicatrization of the affected pleural cavity, empyema and pleurisy may cause a curvature, with curvature towards the healthy side There is slight or no vertebral rotation Congenital heart disease in children, and chronic pulmonary tuberculosis

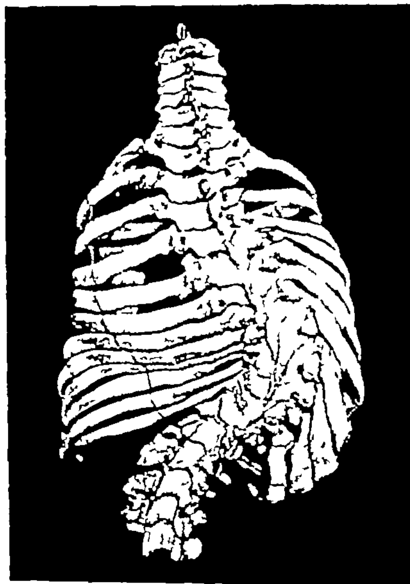


Fig. 141. Scoliotic spine secondary changes in vertebrae and ribs. (Taylor)

because of the fibrosis and cicatrization of the lung as in empyema and pleurisy may be causes of scoliosis

10 Nasal Obstruction If persistent this often leads to contracted thorax, kyphosis and finally scoliosis in this order

11 Cicatrices from Extensive Burns These followed by contracture in the region of the thorax and arm are also etiological possibilities in some instances

CLINICAL TYPES OF SCOLIOSIS

Functional Variety This is a type of scoliosis in which the structural changes are incipient and remediable It is a type seen frequently in

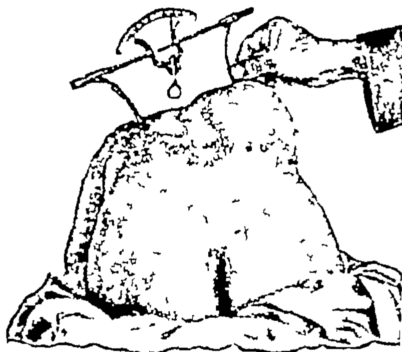


Fig. 142. Scoliosis. Measurement of rotation of the ribs in the horizontal position by the levelling trapezium. (Schulthess.)

children of school age and the curvature can be corrected voluntarily as the condition is caused by the frequent assumption of a faulty position There are no structural changes in any part of the spine

Structural Variety This is the type of scoliosis in which the organic changes are well established in the vertebrae, discs ribs shoulder girdle, and pelvis Its various forms are

1 Total Scoliosis.
2 Lumbar Scoliosis
3 Dorsolumbar Scoliosis.

4 Simple Primary Dorsal Scoliosis
5 Cervicodorsal Scoliosis
6 Compensated Dorsal Curves

RECORDING OF CURVATURE

A great number of instruments and methods have been devised for recording the curvature of scoliosis One very simple and practical method is to mark the tips of the spinous processes the iliac crests and the angles of the scapulae with a blue pencil, and then to photograph the patient s back through a thread screen, with the screen placed close to the back

Steindler determines the angle of curvature by large x ray plates which include the whole chest He passes straight lines across the plates parallel to the vertebrae or intervertebral discs of each curve, and determines the number of degrees in the angle of the curve Since this method also serves as a record, and an index of the progress of the deformity, or improvement after treatment, it is considered by the author to be the method of choice

TREATMENT

Preventive Treatment Because any predisposing factor should be eliminated as soon as possible early recognition of scoliosis is essential A careful and systematic observation of every child s physique for the detection of cryptic physical anomalies should be encouraged The discovery of a beginning curvature is often delayed until a dressmaker a schoolteacher or a school physician comes upon it accidentally Parents should also be advised to correct bad habits of sitting or standing

During school life, frequent changes in the work routine plenty of exercise and fresh air supplementing the working hours and avoidance of especially long sitting and standing periods should be the rule The natural inclination for the spinal column to bend to the left should be borne in mind and a constant writing posture which favors this position should be avoided

The general physical condition should be watched carefully and kept at a high standard. The child should have sufficient sleep and general muscular weakness should be met with special and ample exercise It is important to maintain the mobility of the spine and to strengthen the

weaker groups of muscles with the proper exercises The diet should be well balanced and should include all vitamins in the natural form where possible. Where the vitamins and minerals cannot be supplied adequately in the diet this deficiency should be adjusted by the giving of them in prepared form. At puberty, the child must be protected against both mental and physical exhaustion Unilateral defects in the hearing and sight should be corrected and in all forms of developing scoliosis the child should be examined carefully at frequent intervals, over a period of years

Rickets demands prompt and systematic specific treatment, and the avoidance of faulty attitudes especially while the bones are in a malleable state

Treatment for Functional Scoliosis In this type of scoliosis there are no structural changes in the bones or soft parts the condition requiring correction is essentially one of faulty posture Such a curvature, which is seen only in children, can be corrected voluntarily by the child himself since it is caused by a faulty posture which the child tends to assume frequently and for long periods of time Treatment is indicated in this type of curvature, lest the faulty posture become the characteristic attitude, and the scoliosis develop into the structural type as happens in a small percentage of cases

The treatment of this type of case naturally must be of two kinds

1 *General Treatment* Every possible cause should be removed The patient s habits should be studied carefully and if faulty corrected Physical defects such as defective vision or hearing or a short leg should be corrected If the child is undernourished an adequate diet and a tonic should be furnished Clothing if improper should be adjusted to allow free motion of the spine trunk, and extremities. Mental and physical fatigue should be avoided and an out-of-door life encouraged

2 *Corrective Treatment* This should include gymnastic exercises to develop and increase the tone of the muscles and in some cases, special exercises to strengthen a particular group of muscles to promote the habit of holding the body erect and in the proper symmetrical position Elaborate pieces of gymnastic equipment are not essential in the strengthening of the musculature but the patient s willingness to work under supervision is essential

Treatment for Structural Scoliosis The treatment of idiopathic scoliosis, and all forms of structural scoliosis has challenged the ingenuity of the orthopedic surgeon for many years and the treatment is

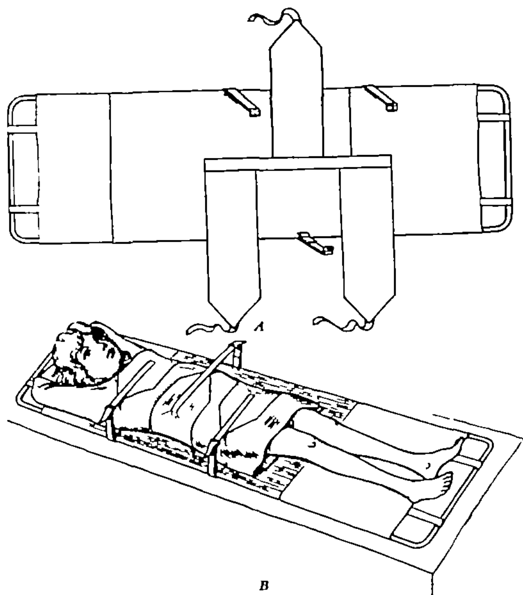


Fig. 143-A and 143-B. Albee modification of a Bradford frame for the correction of scoliosis in children with the patient in the reclining position. Two broad bands of heavy ducking are placed on one side, with one on the opposite side. Correction pressure is applied by buckles at ends of metal posts indicated. (*From Orthopaedic and Reconstruction Surgery by F H Albee—W B Saunders Co., 1921*)

unfortunately still very uncertain in many clinics The number of failures encountered and the variety of therapeutic corrective procedures devised confirm this conviction

The problem of scoliosis has been characterized as one of the stumbling blocks of the orthopedic surgeon, and a review of the treatment of scoliosis of the structural type does present a gloomy picture When a conservative method is employed, the ultimate result is always questionable For this reason, the fusion technic has proved a godsend Before the inception of such operative work, the surgeon was absolutely helpless in the majority of cases To have a coöperative child and his parent come month after month sometimes year after year for treatment—only to see the deformity gradually increase after everything known had been done—was too often his painful experience.

The senior author was ultraconservative at first in recommending the bone graft for scoliosis But as time has passed, the great advantage of the graft has been increasingly realized, and it is now the authors firm conviction that the graft is as trustworthy for scoliosis as for tuberculosis, and is deserving of the same enthusiastic use.

Once it has been determined that a conservative treatment will not be sufficient to prevent further deformity if the deformity is great the patient should be placed in bed for a few weeks and the deformity corrected as much as possible by a turnbuckle cast See Figure 13 Following this a bone graft is inserted through a window in the cast The authors are convinced that in scoliosis the great amount of bone needed for the prevention of increasing deformity is more than that available locally and by the removal of the spinous processes to obtain bone the influence inhibiting rotation is lost and the leverage action causing derotation is removed.

Even 35 years after its insertion the bone graft has been found to hold rigidly

The scoliotic deformity being produced by the synchronous interaction of abnormal postures their fixation by the constant operation of the fundamental cause increased by the superimposed weight of the upper trunk, shoulders, head and neck and loss of tone of the spinal muscles—local treatment must be directed at the simultaneous breaking of all the links in this vicious chain

Corrective treatment in the following forms proves most effective

1 Maintenance of the general health
2 Daily periods of recumbency

3 Postural training to give the patient an educated muscle sense, to procure instinctively correct attitudes

4 Exercise both active and passive, supplemented by physiotherapy



A *B*

Figs. 144-A and 144-B. *A*, A case of paralytic scoliosis before correction and insertion of graft. *B* Same case as *A*—one year after the insertion of a graft into the tips of the transverse processes of the apex of the convex side of the worse curve. The graft included the thoracic vertebrae from the fifth to the twelfth inclusive The marked straightened condition and increased stability of the back is most gratifying. *(From Orthopaedic and Reconstruction Surgery by F H Albee—W B. Saunders Co., 1921)*

If the foregoing methods—severally and collectively—prove unavailing resort must be made to

5 Rapid correction by manipulation, supplemented by operative correction by means of the strong inlay bone graft—in conjunction with the

turnbuckle cast, used for its preoperative corrective influence and for its postoperative fixation

6. Palliative spinal support in intractable cases

A critical survey of the therapy of scoliosis is warranted, since, in many hospitals, a rational system of treatment of the structural type of case has not developed. The senior author's extensive experience gained in the



Fig. 145 *A* Idiopathic scoliosis. Spine at onset of conservative therapy *B* cork screw spine after prolonged treatment by corrective exercises, braces, plaster jackets and traction. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

operative treatment of spinal diseases and deformities for more than 25 years forces him to indict certain therapeutic measures as unsound fundamentally Many of his cases were especially instructive because of previous abortive attempts at treatment—particularly the injudicious use of braces casts or plaster jackets. Time lost by their application in many cases seriously interfered with a satisfactory realignment of the spine by surgical means at a later date for unfortunately the offending structures in early idiopathic scoliosis the muscles tendons and ligaments are

weakened by the suppression of the stimulus of function It should be remembered that in treating curvatures with a brace, one attempts to correct the spine indirectly through pressure on the thorax The ribs are elastic structures, and a great deal of the force exerted will be spent merely on increasing their angulation, or in changing the relations at the costal vertebral junction When the brace is removed the spine collapses like an abandoned accordion, as Whitman has stated Obviously it is treacherous to remove the brace, and both patient and physician cling to



Fig. 146. Same as Fig. 145 Four years after operation showing bone graft holding securely the corrected position of ribs after they were extracted from the pelvis at operation. Union with tenth rib at *A*. Note increased density of tenth rib—also hypertrophy of spinal graft. Full correction not attained because of extreme contracture of soft tissues on concave side following extended conservative therapy This patient indulges in the most strenuous exercises, including skating and tennis. (*From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York*)

it in desperation Furthermore the utilization of the brace in a mild case of scoliosis will often weaken the inactive muscles increase the angle of deviation, and set up a vicious cycle converting a non progressive spinal deformity into one of active increase

Lemesurier Technic An interesting method of correcting the primary curve in scoliosis before performing the fusion operation is reported by A. B Lemesurier of Toronto He places his patient on the side in a hammock made of ordinary fish net with a one inch mesh and little yield The

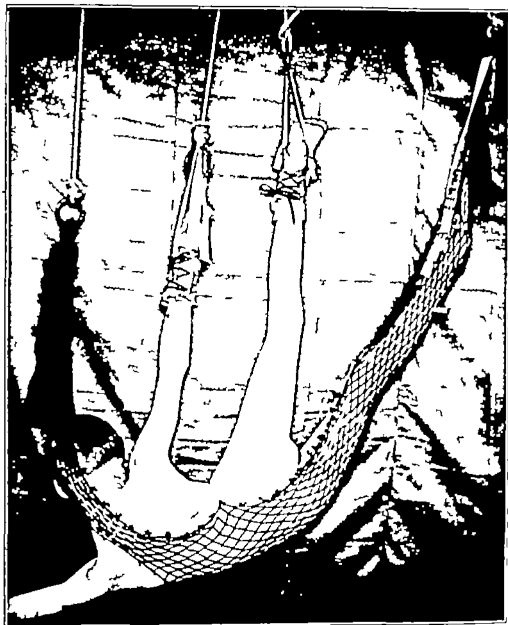


Fig. 147 A. Patient suspended in hammock, ready for application of plaster



Fig. 147 B. Application of sponge rubber padding.

two ends of the hammock are then slung to the ceiling as shown in Figures 147 A, 147 B, and 147 C, in such a way that the body is bent rather sharply in a direction to correct the primary curve. The patient is placed in the hammock for increasingly long daily periods until he be-



Fig. 147-C. Completed jacket from the back. *(From Journal of Bone and Joint Surgery.)*

comes used to the position. While he is hanging in such a position, a plaster extending from the head to one foot is applied, and a window cut in the back to permit the operation. After the operation, the patient remains in this plaster for about 3½ months.

The main advantages claimed for this method are speed of execution and decrease of time required for preparing the patient for operation.

EARLY TREATMENT

The treatment of early idiopathic cases by corrective medical gymnastics is rational therapy Curvatures are overcome by strengthening the musculature not undermining it In this manner early non progressive cases are easily eliminated

Position in Regard to Operation If the spine shows a tendency toward increase of the deformity, after corrective medical gymnastics without braces have been carried on with periodic x ray examinations to determine the progress or non progress of the lesion operative correction and stabilization of the spine is recommended Before the employment of the bone graft such cases were universally disappointing to the surgeon who with hands completely tied was forced to watch the progressive development of such deformities

It was during 1908 that the senior author conceived the technic of producing extra articular arthrodesis of the spine by means of the bone graft and since that time clinical experience has proved the fundamental biophysiological soundness of this method Although the profession was quick to adopt the operation in the treatment of Pott s disease in preference to conservative therapy there has been a marked hesitancy about following a similar course in the case of scoliosis despite the senior author s success with this method over a period of 25 years

The routine attempts at fusion of the scoliotic spine without the use of the autogenous bone graft in early cases, in vogue in certain cases has been opposed by the authors chiefly because of the magnitude of the operation and the uncertainty of fusion In the most competent hands the operation often requires from 60 to 90 minutes Since the chain of arthrodesed articulations is no stronger than its weakest link, when marked rotation of the vertebrae has occurred, many of the articulations are inaccessible, and thus the mechanical basis of the operation is incorrect The complete fracturing of the spinous processes at their bases, in the Hibbs type of operation, tends to encourage further rotation and flexion as the center of gravity passes anterior to the bodies of the vertebrae in the dorsal region and the tendency of the spine to forward flexion is counteracted by the ligamentous structures (the interspinal and supraspinal ligaments) attached to the spinous processes Furthermore there are im

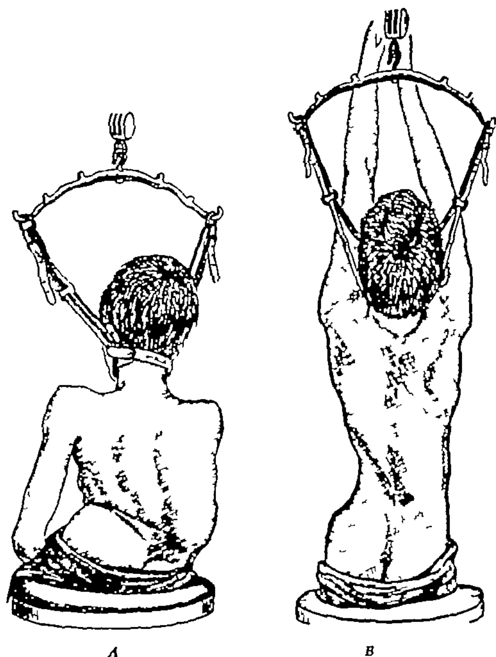


Fig. 148-A and 148-B Self-suspension, illustrating the effect of traction in lessening deformity induced by paralysis. (Gibney) In such cases support to maintain the correction is essential, and the tibial bone graft is of great value. *(From Orthopaedic and Reconstruction Surg., by F H Albee—W B Saunders Co)*

portant muscle attachments involved—the multifidus semispinalis and sacrospinalis groups Denuding and fracturing the processes, and releasing the favorable action of these muscles and ligaments, tends to encourage rather than to correct further deformity The extended period of postoperative traction on a Bradford Frame, followed by a cast and brace for approximately 1½ years (as practised by some) does not invite recourse to surgery

The incidence of failure of fusion when the Hibbs technic has been employed is high according to recent figures, as high as 47 per cent according to Brogden *

The Albee technic is calculated to encourage corrective biomechanics and mobilizes the maximum osteogenesis In contrast to the fragmented sluggish osteogenetic chips of vertebral bone used in the Hibbs procedure the tibial graft used in the Albee method is an active osteogenic brace and splint which reinforces itself by proliferation of bone at points of greatest stress, according to Wolff's law It is interesting to note that when the graft is implanted in the spinous processes, fusion occurs early and proliferation of bone is great This is entirely in keeping with the mechanics of the vertebral articulation The tip of the process is subjected to the maximum stress, or *vice versa* and the greatest corrective effort is applied at the greatest distance from the fulcrum (the tip) Although this is not always possible the Albee operation utilizes the potential leverage to its maximum This leverage splint action of the strong tibial graft serves in two ways when being implanted, as it furnishes the surgeon with a potent means of correcting the rotary and lateral deformity of the spine by effective splintage of the column itself

IDIOPATHIC SCOLIOSIS

In severe cases maximum correction is first obtained by the use of a turnbuckle cast (see Fig 13) This may require only a few weeks or it may require a few months Following this an operation is performed through a window cut in the cast over the area of the primary curve to be fused The cast is maintained in position for approximately three months after operation. Physical therapy is then instituted If the area of the

* Brogden, W E., Journal of Bone & Joint Surgery 18 1027 1938

spine involved is extensive necessitating the inclusion of both curvatures within the field of operation then a second cast is applied After the primary curve has been corrected and fused, the second curve is corrected in the same way by means of a turnbuckle cast and a second bone graft usually about four months after the operation for the first curve. How



A



B

Fig. 149 A. Patient A. N Idiopathic scoliosis. Spine at onset of treatment. B after wearing plaster of paris jacket constantly for one year (*From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York*)

ever, control of the primary curve is usually sufficient and a second operation is necessary in only ten per cent of the cases

PARALYTIC SCOLIOSIS

During the initial febrile stage all the general rules of treatment applying to all types of infantile paralysis should be followed that is restraint in bed, or on a gas-pipe frame to restrict motion of the vertebrae of the involved area of the spine Following the febrile stage external supports such as plaster of paris corsets braces metal frame, self suspension by the Sayre apparatus should be applied, together with corrective exercises, until no further improvement is noted thus indicating that the


B


A


C

Fig. 150. *A* same as Fig 149 Correction of lumbodorsal curve with turnbuckle and hinged cast. Turnbuckle not visualized. Compare with Fig. 149-B *B* roentgenograms showing permanent fusion of lumbodorsal spine by means of bone graft, *A*, to prevent recurrence. Correction of dorsal curve by turnbuckle Patient ready for second Albee fusion. *C* roentgenogram taken five months after second fusion operation. The lower pole of graft *B* was interlocked with upper pole of graft *A* at *C* so as to abolish articulation, construct an unyielding bony ridge and as well to insure permanent correction. Note hypertrophy of graft *A*. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

paralysis still persists and residual spinal deviation is a result of permanently destroyed motor nerve cells

Often in the severely affected cases it is impossible to maintain correction of the spinal deviation by means of outside support, and when the patient stands, the spine collapses into an S curve inside the brace because of deficient muscular support The inability to maintain the

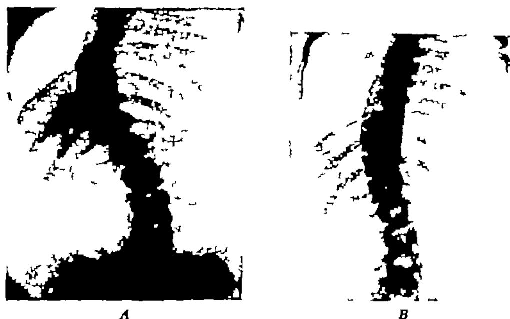


Fig. 151 *A* Paralytic scoliosis. *B* Four months after spine fusion with tibial graft showing permanent correction of curvature. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

correction by external means is due to a combination of the following factors

1 The large size of the thoracic cage its constant movements and ever changing volume under the influence of respiration

2 The fluctuation in the degree of distention of the abdomen and its contents

3 The location of the spine in the extreme posterior portion of the trunk

4 The physical impossibility of immobilizing externally individual vertebra, one with another on account of the aggregation of 21 moving vertebral bodies each a unit of relatively small size

In such instances, on account of the unbalancing of muscular forces, and the marked tendency of the deformity to relapse it is impossible to maintain a general alignment of the vertebral segments

After two years have elapsed the surgeon must decide whether the muscle weakness and the resulting curvature are sufficient to warrant the implantation of a more corrective and trustworthy bone graft support

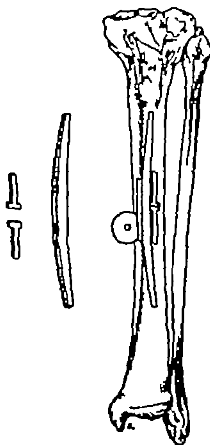


Fig. 152. Method of cutting curved graft and two bone keys for fusion of the spine in severe scoliosis. (See Fig. 153) *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

ALBEE TECHNIC OF OPERATION

Before the operation if a turnbuckle corrective cast has not been found necessary a plaster of paris bed with firm lateral walls should be molded to the back and sides of the patient s trunk, and allowed to harden while the patient is held in the corrected position This plaster splint is then removed and laid aside until after the operation The field of operation on the back, as well as on the leg is prepared by the iodine method Six

to eight spinous processes as the need may be, at the apex of the most acute curve, are laid bare on the convex side by a curved skin incision, similar to the skin incision described in the bone graft operation for Pott s disease. The muscles and ligaments over the tips and between the spinous processes are split into approximately equal halves with a scalpel

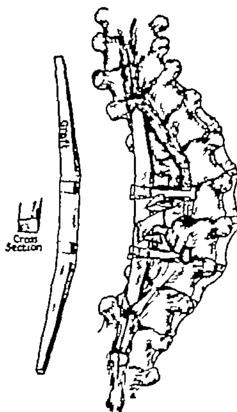


Fig. 153. When extreme degrees of curvature are encountered and manual correction at the operating table is resisted by contracture of the soft tissues—the graft is inlaid as shown above. The two vertebrae at the apex of the curve are immobilized by bone keys coapting the spinous processes and the longitudinal graft. Drill holes are made before removal from the tibia. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

The spinous processes are split longitudinally into halves by means of a wide osteotome and at the same time one half is set over to allow room for the graft.

With a flexible probe and calipers the contour and length of the desired graft are determined while the spine is forced manually by the surgeon and his assistants into the position of maximum correction. The *tibia is flexed on the thigh* and its anterior crest and anteromesial surface

laid bare The flexible probe pattern is applied to this exposed tibial sur face, and the desired graft is outlined in the periosteum with a scalpel The motor saw is then made to cut along the periosteal outline, and the graft is removed including the full thickness of the cortex at the ends crest, and central portion

The graft is then placed in the bed already prepared for it between the halves of the split spinous processes While the patient is held manually in the corrected position the strong split ligaments and muscles are drawn over the graft with interrupted sutures of heavy kangaroo tendon In this way the graft acts as a corrective splint, and both the rotary and lateral deformity of the column are corrected to the maximum degree, by pull ing it to the graft by the strong strands of kangaroo tendon This is very effective because the pressure is exerted on the column itself and not on the ribs or soft parts The graft must be of great strength, especially at its central portion and should be suited to the size of the patient and the mechanical demands of its location

In an adult the graft should measure at least ⅝ of an inch from the crest each way, so as to include the antero-internal and antero-external cortex. A strong tibial bone graft implanted into the spinous processes serves the surgeon as an internal lever and splint by which an unusual amount of the scoliotic deformity can be corrected at operation It also by virtue of its internal splintage inhibits the further increase of the lateral deviation, and its amalgamation into the spinous processes of several of the vertebrae in the most pronounced portion of the curvature prevents further rotation of the vertebrae upon themselves The graft splint serving as a lever also enables the surgeon to diminish the rotary de formity at operation

The patient is bandaged into the plaster of paris bed previously pre pared Additional correction may be accomplished by placing pads inside the cast at selected places Recumbency in the plaster of paris bed is main tained for from 10 to 12 weeks Following the immediate postoperative fixation a well molded plaster of paris jacket or corset brace is applied to those cases which need further supplemental support In some cases temporary external support is necessary because of the unbalanced muscle pull of the spinal and abdominal musculature and the strong tendency

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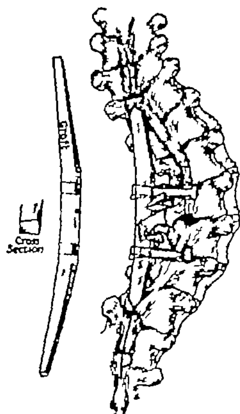


Fig. 153. When extreme degrees of curvature are encountered and manual correction at the operating table is resisted by contracture of the soft tissues—the graft is inlaid as shown above. The two vertebrae at the apex of the curve are immobilized by bone keys coapting the spinous processes and the longitudinal graft. Drill holes are made before removal from the tibia. *(From Albee, Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

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to a relapse of the deformity above and below that portion of the spine fixed by the bone graft.

PROP GRAFT

In the most extreme type of paralytic scoliosis where the lower ribs telescope into the pelvis the senior author for 15 years has been doing an

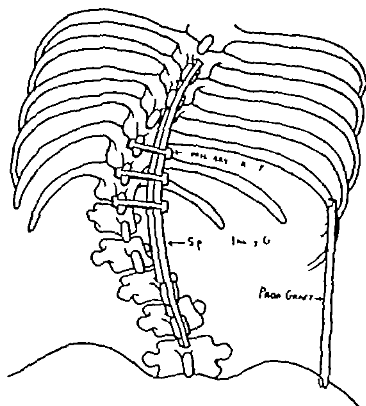


Fig. 154. Schematic representation of prop graft (Fig. 11) Note interlocking of graft and tenth rib also auxiliary grafts at right angle to spinal graft, necessary in extreme degrees of curvature. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

operation (supplemental to the inlay graft) which has given excellent results In brief it is a bone graft prop from the distal end of the tenth rib to the crest of the ilium This rib has been chosen because, being strong in itself it provides a firm means of anchoring the graft to the thoracic cage

Technic An incision is made from the anterior end of the tenth rib to the crest of the ilium slightly anterior to the axillary line developing the anterior end of the tenth rib and the crest of the ilium. The lower

border of the rib is shaped into a wedge to receive the wedged notch of the graft end The crest of the ilium is shaped in a similar fashion

With the partial correction already obtained from the action of the frame upon which the patient has been lying for weeks before the operation or by a turnbuckle cast plus strong lateral and upward digital pressure by assistants the ribs are pulled upward to the maximum and the distance between the ribs and the ilium is measured by either a flexible

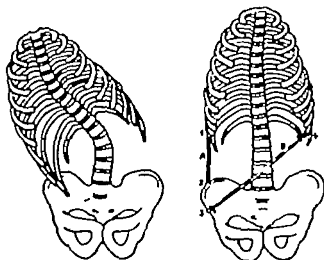


Fig. 155 Vertical prop graft *A* at 1 and 2 augmented by strip of fascia lata *B* secured to the ilium at 3 and the tenth rib at 4 on the opposite side. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

probe or by calipers The antero-internal surface of the tibia is then laid bare, and a strong graft ⅜ inch wide, and of the length determined by the calipers or probe is marked off and cut out by means of the twin saw After its ends are notched, this graft is then put in place and the mortising effect of the notches in contact with the convex wedge surfaces already prepared upon the tenth rib and ilium, are sufficient to hold it firmly in place, as the ribs have a strong tendency to approximate the ilium. The careful suturing of the soft parts around the graft gives further assurance of immobilization

HIBBS OPERATION

The technic of the Hibbs operation has been described in detail on page 207

The Albee bone graft method, and the Hibbs method, both have eir advocates and both bring about fusion of the scoliotic spine but ie authors are convinced that the Hibbs operation, in some cases, de ands a higher degree of osteogenic power than the vertebral bone can : expected to supply

In addition to the reasons already discussed in the previous chapter, ie authors prefer the use of the bone graft in scoliosis because

1 A shorter and simpler operative procedure is always desirable, id this is especially true in scoliosis where the distortion of the chest ntents increases the shock In competent hands the Hibbs technic often quires from 60 to 90 minutes, as against as little as 15 minutes for e bone graft

2. The long confinement in plaster casts and jackets required for sion without the use of the bone graft, increases unnecessarily the rophy of the weakened spinal muscles and ligaments

3 It is difficult and often impossible to reach all of the articular facets, ie to the rotation of the vertebrae Hence the possibilities of fusion e greatly reduced

4 Recent reports show as high an incidence of pseudoarthrosis as ' per cent following the use of Hibbs technic for scoliosis, according Brogden of the Ruptured & Crippled Hospital in New York. Un- ubtedly this is due in part to the low osteogenetic potentiality of rtebral bone

5 Following the failure of a Hibbs operation, it is difficult to insert :ontinuous graft.

6 Superimposed shadows of numerous potential areas of arthrodesis id to obscure the x ray picture making a diagnosis of complete fusion ry difficult (It is often impossible to diagnose a pseudoarthrosis llowing such operation by x rays)

7 From a mechanical standpoint it must be realized that fracturing e spinous processes at their bases disturbs important ligamentous and ascular attachments that are vital for resistance to increase of deform- particularly rotation

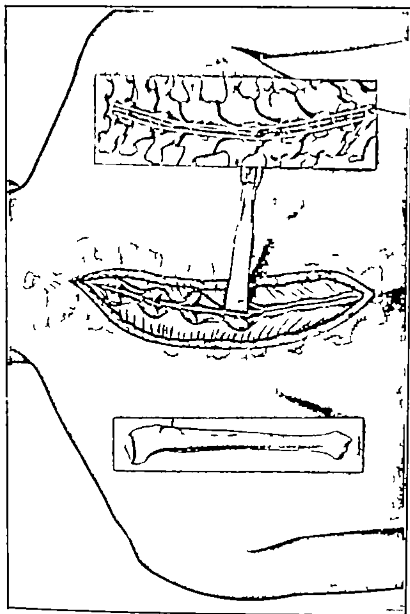


Fig. 156. Fusion of the spine for scoliosis. Spinous processes split and small segment turned to each side. Inserts show method of removing thin flexible grafts. Grafts placed in apposition to split spinous processes. *(From Operative Orthopaedics by W. C. Campbell C. V. Mosby Co. St Louis.)*

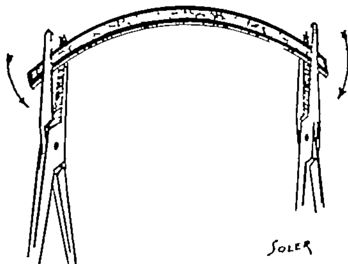


Fig. 157 Drawing illustrating flexibility of these thin grafts—Inclan s method.

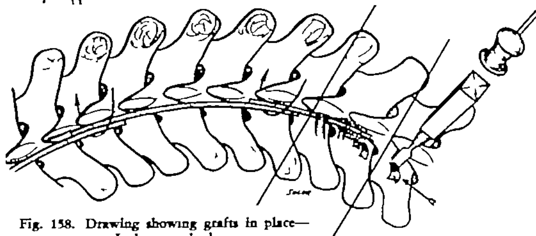


Fig. 158. Drawing showing grafts in place—Inclan s method.

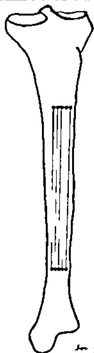


Fig. 159 Drawing showing multiple thin grafts, to be taken from tibia—Inclan s method.

DRAWINGS ILLUSTRATING INCLAN'S METHOD

MODIFIED HIBBS PROCEDURE

Campbell and others prefer the combination method of placing thin osteoperiosteal grafts from the tibia into a bed formed by splitting the spinous processes and turning a small segment to each side In this technic, the thin flexible grafts obtained by the method shown in Figure 159, are placed in apposition to the spinous processes In instances where the ribs are prominent a portion of a rib is sometimes resected and used as an additional graft at the time of this operation

THE INCLAN METHOD

Inclan uses long finger grafts taken from the tibia as illustrated in Figures 157 158 and 159 These grafts are bent to suit the lateral curvature of the spine and are placed on the roughened surfaces of the laminae and spinous processes from which small shavings have been removed as in the Hibb s operation The grafts are placed in shingle form and sutured with very thin steel wire to the bases of the spinous processes to hold them in place

STEINDLER'S CONSERVATIVE COMPENSATION DEROTATION TREATMENT

Steindler divides the types of scoliosis seen in private practice into five groups

1 Those which realign or compensate spontaneously and with adequate muscle power at their disposal maintain such correction

2. Those in which adequate compensation can be accomplished by conservative means without fusion operations and in which, too adequate muscle tone can be maintained with conservative measures

3 Those in which adequate compensation can be maintained, and where adequate muscle power can be developed but because of marked congenital osseous or adaptive changes, although the patient has good musculature, compensation is likely to break down He also includes in this group the more severe habitual cases still progressing the congenital cases and those with an oblique fifth lumbar vertebra. He advises fusion of this entire group

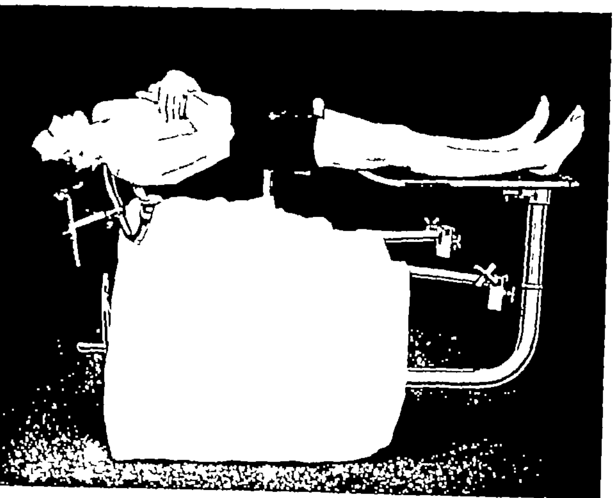


Fig. 160-A. Derotation of scoliosis by means of the Albee-Comper Fracture Table.

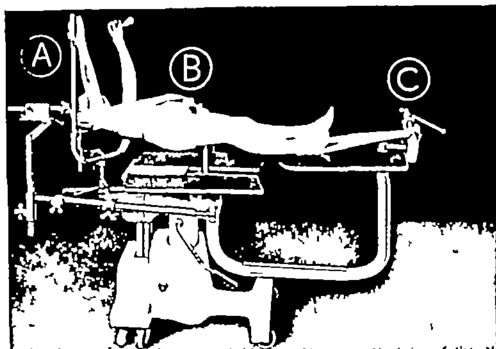


Fig. 160-B. Figure shows extreme flexibility of the Albee-Comper Fracture Table for application of preoperative or wedge cast in the treatment of scoliosis. First, counter rotation and counter traction is obtained by fixation of the pelvis with a plaster cast which immobilizes the hips on the sacral rest and perineal post. Further counter-traction can be obtained by applying traction to either one or both feet through turning the winch at (*C*). For lateral traction on either side of the body in the cervical, thoracic or lumbar region, use the table's regular leg traction (*B*). For traction behind the head, use the other leg traction (*A*).

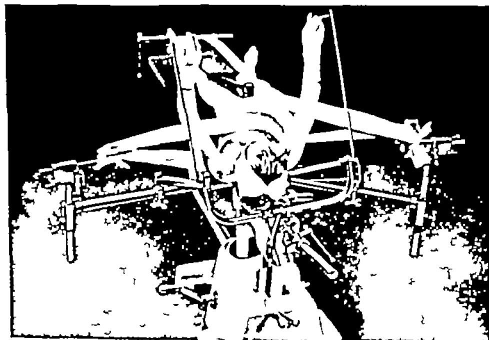


Fig. 160-C. Shows complete corrective control in derotation and also in lateral bending. Can be obtained by the shoulder yoke which is universally adjustable and locks firmly in any plane or at any angle.

4 Those in which alignment is possible but adequate musculature is lacking This includes most paralytic cases which he feels should also be fused

5 Those which cannot be realigned, due to severe structural deformities and those with a severe cervico-thoracic curve For these, fusion is recommended If the curve is stationary he advises external support

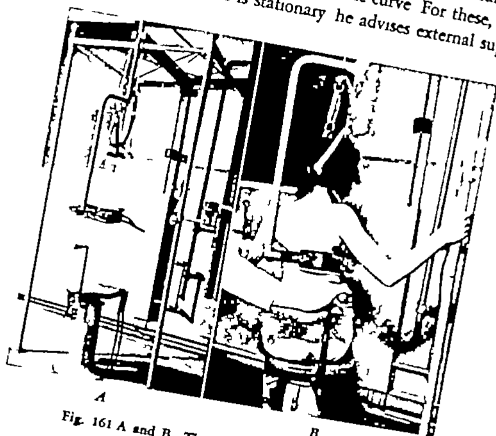


Fig. 161 A and B The Grieve Derotation Chair

Steindler is particularly interested in those of the second group and he considers adequate alignment has been accomplished when a line drawn from the middle of the bimastoid line passes through the mid point of the shoulders and strikes the gluteal cleft, the musculature being developed by special exercises to maintain this alignment with out external support This method attempts to develop such proper alignment by the development of ensatory curves

The program of treatment i First compe ... arried as near as possible to the poi t body and ment, which means the development t contralater rves.

The degree of compensation, irrespective of length, is measured by the angular values of the two curves Next correction of the curves themselves by derotation is carried out under elimination of superincumbent body weight by recumbency or traction

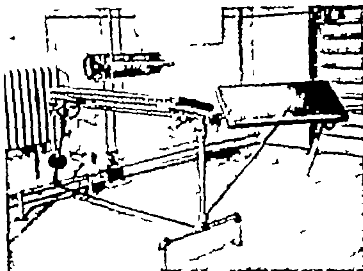


Fig. 162 A Derotation table.

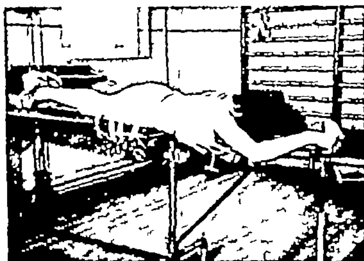


Fig. 162 B. The patient is fixed on the table as illustrated. The physiotherapist operates the table by means of two lever arms (not illustrated) which are attached to each segment of the table.

Derotation is carried out in both the sitting position under traction in the Grieve Chair and in the recumbent position on his derotation table. Between treatments the spine is protected from collapsing by traction

in recumbency, or by means of a spinal brace with a leg and head attachment.

The correction that is obtainable depends for its maintenance upon the development and rehabilitation of the musculature Steindler feels that the decision for or against fusion rests upon the extent to which the musculature can be rehabilitated together with the degree of compensation obtainable.

The Anterior Posterior Deformities of the Spine

There are two types of anterior posterior deformities of the spine, namely, *kyphosis* and *lordosis*

KYPHOSIS

Kyphosis is an anterior posterior curvature of the spine in which the convexity is directed posteriorly Clinically, and for the sake of clarity, kyphosis may be divided into three distinct varieties

1 Kyphosis of infancy and early childhood

2 Kyphosis of adolescence

3 Kyphosis of adults

Kyphosis of Infancy and Early Childhood

Etiology This type of kyphosis is due to a variety of conditions, namely

1 Feeble muscular development

2 Rickets tuberculosis, and other diseases of the vertebrae.

3 Poliomyelitis pseudohypertrophic paralysis, progressive muscular atrophy idiocy cretinism and allied conditions, sciatica, and locomotor ataxia.

4 Congenital malformations

Treatment The treatment of *kyphosis of infancy and early childhood* is primarily the treatment of the disease causing the kyphosis



Fig. 163. A case illustrating marked kyphosis with acquired ankylosis from tuberculous involvement. The texture of the bone varies greatly from that of the normal vertebrae. Female aged 31 *(From Roentgen Diagnosis of the Extremities and Spine by A. B Ferguson Paul B Hoeber N Y., 1941)*

Kyphosis of Adolescence

Etiology Any of the various causes of *kyphosis of infancy and early childhood* may also be etiological agents of adolescent kyphosis However the most frequent causes are

1 Muscle weakness
2 Osteochondritis and epiphysitis, with the attendant intervertebral disc changes
3 Congenital malformations
4 Rickets tuberculosis and other diseases of the vertebrae

Clinical Features Kyphosis of adolescence occurs most often between the ages of 12 and 18 and usually affects the dorsal spine. The commonest symptoms are backache and fatigue However the symptoms vary with the etiological agents and in many cases the patient is found to be entirely asymptomatic, only seeking the advice of a physician because of the kyphotic deformity

Burns and Ellis in discussing the fact that osteochondritis and epiphysitis are apparently parallel conditions occurring at different periods of growth point out the following abnormalities to be watched for in the vertebral bodies

1 Increase in the size of the notch at the upper and lower anterior angles of the bodies of the vertebrae, and possible variation from the norm of the size and density of the epiphyseal centers. (Considered an epiphysitis)
2 Wedging of the vertebral body as a result of lack of endochondral growth in the cartilaginous interspace. (Considered an osteochondritis)
3 Cup-shaped areas of sclerosis appearing in the body of the vertebra around the nuclear intrusion, in lateral x rays these usually appear somewhat behind the midline of the vertebra (Considered a sequel to an osteochondritis)

Diagnosis Diagnosis is made after the history of the case has been studied in conjunction with the findings of thorough physical and x ray examinations

Treatment The treatment of kyphosis of adolescence is of a dual type

1 Treatment of the disease (if any) that is causing the kyphosis

2 Treatment of the kyphosis itself If due to muscular weakness, proper physiotherapy with muscle stretching and training may be all that is required In certain cases some type of brace may be necessary



Fig. 164. Wedging round back in a female aged six years and five months. The posterior fourth of the body is not wedged. Both surfaces are affected. There is no compression area. A vascular pit and groove are present anteriorly at the middle of the body The facets are not subluxated. The spinous processes are not spread. Every detail of the shape of the affected bodies is different from compression fracture. There is no dorsum rotundum in this case because kyphos at a tuberculous lumbar lesion tends to make the dorsal spine extend. *(From Roentgen Diagnosis of the Extremities and Spine by A B Ferguson Paul B Hoeber N Y., 1941)*

In the severest type of case, spinal fusion by means of a tibial graft may occasionally be necessary

Kyphosis of Adults

In the past there have been many terms used to describe the various clinical varieties of anterior posterior deformity in adults such as round

back, flat back, hollow back, round and hollow back, etc However, as a distinct physical entity they can all be brought most conveniently under the heading of *adult round back* The following description of adult round back, in general, covers the course and treatment of all these clinical types

Adult Round Back

Etiology Adult round back may be caused by occupation—as in the case of cobblers and tailors whose working posture is one in which there is constant flexion of the spine It may be due to the retrogressive osseous and intervertebral changes which accompany old age It may also have for its etiology a definite pathological entity such as

1. Muscular and gonorrheal rheumatism
2. Scoliosis
3. Osteitis
4. Arthritis deformans
5. Osteomalacia
6. Bronchitis and emphysema
7. Hyperparathyroidism
8. Progressive muscular atrophy
9. Poliomyelitis
10. Rickets
11. Acromegaly

Clinical Features The kyphotic deformity is characteristic in appearance Usually there are complaints of general fatigue and of pain and weakness in the back. These symptoms vary of course, according to the etiology of the kyphosis

Treatment In early cases education as to correct posture, and spinal extension by means of appropriate gymnastics for stretching and pulling back the shoulder muscles and the anterior part of the shoulder girdle, may prove all that is necessary However in more advanced cases such measures may not be sufficient, and it may become necessary to use a brace or a plaster jacket in addition For the severest type of case, and especially for those having a great deal of pain it is best to perform a fusion

Lordosis

Lordosis is an anterior posterior curvature of the spine in which the concavity is directed posteriorly

Etiology This increase in the normal anterior curvature of the spine is almost invariably compensatory and most often secondary to some other deformity of the spine However in other instances it is not com



Fig. 165 Marked collapse of D-8 in male aged four years and two months. Such loss of substance does not occur in wedging round back even when abnormally prominent vascular grooves, as at D-9 and 10 indicate the probability that round back will develop later At D-9 the vascular groove is prominent posteriorly as well as anteriorly and extends almost across the vertebral body (A P view) (*From Roentgen Diagnosis of the Extremities and Spine by A. B Ferguson. Paul B. Hoeber N Y., 1941*)

pensatory as in spondylolisthesis rickets progressive muscular dystrophy poliomyelitis etc

Clinical Features Protrusion of the abdomen general fatigue and aching back are usually present. Other clinical features may be a waddling gait and some other congenital deformity such as congenital dislocation of the hip

Treatment Treatment most often should be directed to the treatment of the underlying cause rather than to the lordosis itself Improvement

is seldom permanent unless the pathologic factor causing the lordosis is cured In general therapy should include physiotherapy in the form of massage muscle training stretchings and local supports for the weakened musculature

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CHAPTER VIII

Congenital Deformities and Anomalies of the Vertebral Column

In discussing the treatment of congenital deformities and anomalies of the spinal column a classification of the various types and kinds—in general the classification of Perrone—seems desirable These fall naturally into two main divisions as follows

Vertebral deformities without malformation of other parts.

1 Increased number of vertebrae.
2 Deficiency of vertebrae, or of parts of vertebrae.
   (*a*) Spina bifida.
   (*b*) Spina bifida occulta.
3 Synosteosis of vertebra.
4 Torticollis or wry neck.

Vertebral deformities with malformation of other parts

1 Abnormalities of the clavicle.
2 Fusion of the ribs
3 Cervical ribs and scalenus anticus syndrome
4 Spondylolisthesis and prespondylolisthesis

Vertebral Deformities Without Malformation of Other Parts

INCREASED NUMBER OF VERTEBRAE

The instance of this anomaly throughout medical literature is quite rare, and is in reality of no clinical significance except in cases of hemivertebra.

Hemivertebra This anomaly is due to a lack of formation, or a cessation of growth of either one or both of the growth centers in the body



Fig. 166. Marked wedging of the body of L 2 but most of the anterior half of the body is absent, not compressed. There is no impaction area. All bone appears healthy. Adjacent vertebrae are shaped to fit the deformity. Note particularly the conformation of the disc L 2 to 3 at its posterior half. The bulbous contour indicates the site of the nucleus pulposus and the narrow isthmus anterior thereto is definitely developmental. Such a contour is not produced by compression. The lesion is posterior hemivertebra. Male, aged 16. Case CLIx, p. 179. *(From Roentgen Diagnosis of the Extremities and Spine by A. B. Ferguson. Paul B. Hoeber, 1941.)*

of a vertebra. It results in either a wedge shaped vertebra, or in one-half of a vertebra. Because of this, deformity in the form of scoliosis often develops, as the vertebra above gravitates downward on the side of the missing portion

Treatment Many believe that since this deformity frequently becomes fixed, the treatment of choice, until the age of adolescence, is the use of some apparatus to prevent curvature of the spine. If, however the deformity is severe, and limited to a few vertebrae, or the spine is very unstable, as indicated by increasing curvature or any other deformities during the adolescent period, a bone graft fusion operation should be carried out.

It was Codivilla who first suggested excision of a hemivertebra in a case of congenital scoliosis He however rejected the idea as too dangerous in practice though theoretically sound It has been the experience of the authors that the successful employment of the bone graft implanted in the spinous processes for the treatment of paralytic and idiopathic scoliosis points the way to a more practical solution of this delicate problem. So long as motion between the vertebrae can be abolished by a successful fusion operation, congenital anomalies become of little consequence, provided the curvature can be reasonably corrected In a child s spine this is often easily accomplished under anesthesia, because the soft structures on the concave side yield. The graft is inlaid as described for paralytic scoliosis (see p 249) On the other hand, the conservative treatment, which requires years of braces is believed to be unduly prolonged and neither trustworthy nor justifiable in view of the results obtained by fusion By the use of bone graft fusion, permanency is assured, and the possibility of a return to normal childhood greatly enhanced.

It was Compere in 1932 and Smith and von Lackum in 1933 who reported a few cases in which they had performed radical operations to cure scoliosis induced by hemivertebra In these operations practically all of each hemivertebra was removed The technic used by Compere for this operation is applicable to the removal of a hemivertebra in any location The magnitude of any operation of this sort is however so great that it is indicated only in very rare cases

Compere Technic The following technic was employed by Compere for excision of an eleventh dorsal hemivertebra, and an accessory hemi vertebra between the twelfth dorsal and the first lumbar vertebra, both on the left side

A curved incision is made extending from the eighth dorsal to the third lumbar vertebra The left side of the spinous processes and the corresponding laminae, are exposed by means of a periosteal elevator The erector spinae muscles are then reflected laterally bringing into view the transverse processes of the eleventh and twelfth dorsal, and the first and second lumbar vertebrae These are fractured at their bases

An incision paralleling the eleventh rib on the affected side is now made, connecting with the longitudinal incision, and extending later ally for a distance of ten centimeters With a small rib stripper, the eleventh and twelfth ribs are denuded of soft tissue attachments, and the twelfth rib as well as a segment of the eleventh rib, six centimeters in length is excised. A column of spinal muscles is now retracted medi ally and the laminae and pedicles of the vertebrae from the eleventh dorsal to the second lumbar are exposed. The parietal pleura is dis-sected from the bodies of the eleventh and twelfth dorsal and the first lumbar vertebra, exposing their lateral and anterior surfaces Great care must be exercised to avoid unnecessary trauma to the nerve roots

With a small chisel and a dissector the eleventh dorsal hemivertebra on the affected side is removed in several segments The bone is excised from the accessory hemivertebra, leaving a cartilage lined defect The corresponding laminae are only partially excised The spinous processes and laminae of the affected side are again exposed roughened with a chisel and the fragments of bone are turned laterally across the articular facets The previously removed ribs are split longitudinally and placed upon the laminae as grafts extending from the eighth dorsal to the third lumbar vertebra.

(The authors have found rib material very poor for grafting purposes Its osteogenesis is very low and it is very apt to break and disintegrate into bundle shaped small fragments)

After Treatment After the wounds have healed, a Hibbs Ferguson and Risser corrective cast is applied including the leg of the affected side and thereafter gradually correction of the deformity is continued

for three weeks The gap in the cast is then filled in with plaster, and immobilization is maintained until fusion has taken place.

DEFICIENCY OF VERTEBRAE, OR OF PARTS OF VERTEBRAE

The only important clinical instances in this group are the various forms of spina bifida and spina bifida occulta, in which portions or the whole of one or more arches are defective.



Fig 167 Spina bifida and congenital talipes equinovarus, both relieved by operation.

Spina Bifida

Of all the anomalies of the spinal column spina bifida is the most frequent Nikolaas Tulpius first introduced the term *spina bifida* about the middle of the 17th century and since that time it has been generally adopted in the scientific world despite many attempts to supplant it by other terms such as hydrorachis rachischisis and the like Etymologically spina bifida from the Latin and rachischisis from the Greek are synonymous They both describe a cleft in the vertebral column, but since von Recklinghausen s classical monograph on spina bifida in 1866, rachischisis has been used to denote a complete nonunion of the walls of the medullary canal

Spina bifida, for many years, has been a source of much perplexity to pediatrists neurologists and orthopedic surgeons and in spite of the fact that many excellent anatomical and pathological studies of this congenital anomaly have been made, and various methods of treatment devised we seem to be but little nearer the final solution of the problem

Spina bifida is a condition in which a considerable gap occurs in the posterior vertebral wall due to faulty development of the bony lamellae which permits a protrusion of the spinal membrane or cord, or both The hernial protrusion is sometimes covered by skin but usually by a film like structure of variable thickness which is usually attenuated and likely to rupture The protrusion varies in size from a small sac to a spherical mass occupying much of the lumbar region of the back. It is sometimes pedunculated Many other anomalies such as talipes, hydrocephalus exstrophy of the bladder, and imperforate anus are often coexistant

While the skeletal defect is ordinarily in the arches of the vertebrae with the tumor protruding posteriorly (posterior spina bifida), in very rare instances the vertebral bodies are defective with the hernia protruding anteriorly into the abdomen pelvis or thorax (anterior spina bifida)

Spina bifida is classified according to the structures entering into its formation, as

1 Meningocele The type where there is a protrusion of the dura mater and arachnoid but containing no nerve elements A pedicle whose narrow lumen often closes obliterating the sac usually accompanies this form

2 Myelocele. Here the posterior wall of the involved vertebrae is entirely absent, exposing the medullar groove

3 Meningomyelocele In this the sac contains the spinal cord—which is not distended but adherent to its walls—the spinal nerves and fluid The walls consist of dura mater and thin epithelium.

4 Syringomyelocele. The distended cord with spinal membranes and nerves forms the walls of the sac in this type

Infants afflicted with either of the two last named varieties are usually either stillborn, or die very soon after birth

Prognosis The great majority of infants with spina bifida propria do not reach puberty About 80 per cent of such babies die in their first year of various causes such as marasmus coincident infection, and frequently, leaking of the sac on account of sloughing with the result that the fluid escapes, infection occurs, and death ensues from meningitis or myelitis

Occasionally rupture is followed by shrinkage and spontaneous cure Even after the cure of a spina bifida, either spontaneously or by surgical intervention many cases subsequently succumb to hydrocephalus or



Fig. 168. Spina bifida with associated hydrocephalus and left talipes equinovarus.

other sequelae of intracranial pressure, or die from paralysis or a trophic lesion

Palliative Treatment This consists merely of protecting the sac by means of sterile dressings and is in no way curative

Operative Treatment The selection of cases for operation is a matter of prime importance In the final analysis, it will be found that the majority of cases are unsuitable for operative intervention, not because of any technical difficulty in effecting closure of the defect in a very large percentage but rather because of the associated paralysis and other complications which may be wholly uninfluenced by the operation. The contraindications are

1 Hydrocephalus
2 Paralysis of the sphincters
3 Complete paraplegia.

4 Irreparable deformity and the unassociated deformities, and other anatomical defects of a serious nature, such as diastematomyelia, atelomyelia sclerosis of the cord, and ectopic vesica

5 In cases where there are ulcerative processes in the neighborhood of the spina bifida, operation should be deferred until a later date

The closure of the defect by open or operative methods may be accomplished in several ways Methods which have been variously recommended include

1 The employment of a bone transplant taken from the tibia (Albee)

2 The use of a musculo-fascial flap (Bayer)

3 The transplantation of a flap from the fascia lata. Autoplastic (Brodman)

4 A flap of periosteum with base attached, taken from the vertebra (von Bergmann)

5 Osteoplastic closure with a bone flap from the scapula (Skilifossosky)

6 Osteoplastic closure with a bone graft from the crest of the ilium (Bodroff)

7 Filling the defect with fragments of bone from the sacral arches and tuberosities of the sacrum (Zenenko)

8 Closure of the defect by fracturing the bases of the vertebral arches and transferring them to the median line (Dollinger)

9 An adaptation of this principle (#8) by Babcock.

10 The use of foreign materials such as celluloid and silver

The choice of the method used should be based upon the size and situation of the defect, for obviously the closure of a small opening in the upper level of the canal, involving but a single vertebra, with but little separation of the arch, and with the muscles not far apart requires neither muscle nor bone transplant However in cases of spina bifida in which the meningocele has been controlled and a large deficiency of vertebral bone exists together with considerable weakness as evidenced by lordosis or other deformity the bone graft offers an excellent means of strengthening the spine

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Radical Operation for Spina Bifida Two lateral incisions are made vertically and extending well above and below the tumor The sac is opened in a line with these incisions, and the fluid is released gradually either with the patient in Trendelenburg's position but on the face, or in Babcock's position (to avoid cerebral anemia from too sudden reduction of intercranial tension) The sac is turned inside out the nerves

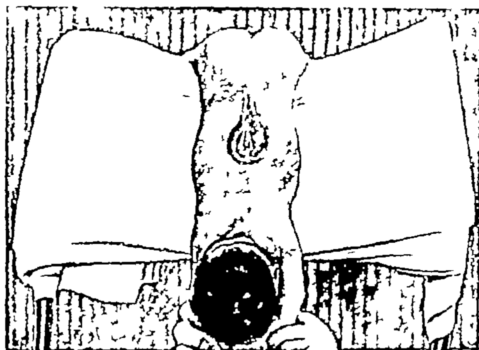


Fig. 169 Babcock's position in operations for spina bifida. (The object of this position is to obviate the danger of too-sudden reduction of intracranial tension.) A blanket is fastened firmly between the upright rod leg-holders on an ordinary operating-table. The child is hung over this by its groins, the legs being fastened by bandages to keep it from slipping. A hot water bottle is placed in front of the blanket, over the child's abdomen, to prevent chilling. (After Babcock.) *(From Orthopaedic and Reconstruction Surgery by F H Albee—W B Saunders Co., 1921)*

dissected out, and the spinal cord freed These structures are then returned to the spinal canal and the sac cut away The neck of the sac is then freed from the bottom of the wound, and as much more tissue as is advisable is resected before it is closed with a purse string suture. Quadrilateral flaps consisting of muscle, fascia and periosteum are made with their bases toward the median line These flaps are sutured with their raw surfaces apposed forming a ridge near the midline The skin is closed with silkworm gut Tension must be avoided by removing

sufficient of the redundant superficial tissues or by undercutting or making lateral incisions in the flanks

Inlay Bone Graft for Spina Bifida (Albee) This technic is similar to that employed in Pott s disease, although modification is necessary on account of the absence of spinous processes and portions of the neural

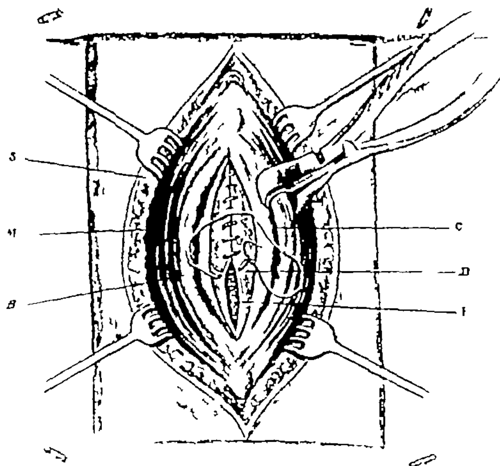


Fig. 170 Babcock s operation for spina bifida. The closure of the separated dura is shown, as is also the mobilization by Satterlee forceps of fibro-osseous ribbons consisting of the rudimentary lamina. *P.*, sutured piarachnoid *D* dura in process of closure *B.*, *C.*, mobilized fibro-osseous ribbons which are to be brought to the median line and sutured *M.*, erector spinae muscle *S* skin.

arches The spinous processes above the cleft, and the remnant of the neural arches of the lateral masses of the last lumbar vertebra and the first part of the sacrum, are reached from each side by two curved skin incisions as it is undesirable to interfere with the nerve tissue which is usually involved in the cicatrix following the operative reduction of

the meningocele The second spinous process above the cleft is split longitudinally and a greenstick fracture produced in each half The first spinous process above the cleft is denuded of its muscular and ligamentous attachments and both sides are freshened Below the cleft, the lateral masses of the fifth lumbar vertebra (or the congenitally deformed stumps of the neural arches, if sufficiently prominent) and the first segment of the sacrum which is usually congenitally hypertrophied are split with the osteotome, and the halves are separated to receive the lower ends of the two grafts

The wounds are packed with saline compresses and two grafts, long enough to reach from the split spines above to the sacrum below are removed from the crest of the tibia. The upper ends are bevelled so that when these surfaces come together the grafts form an acute angle, like an inverted *V* The grafts are placed at this angle in the beds prepared for them and are held firmly in place in their bony contacts by drawing the split ligaments over them with interrupted sutures of medium kangaroo tendon The skin wounds are closed and the patient is placed on a fracture bed for six weeks

Results of Radical Operation on Meningocele The immediate postoperative mortality is about 34 per cent secondary mortality from hydrocephalus convulsions, and so forth is equally great. Thus the ultimate mortality by this method is around 70 per cent

This has been the finding of other authors, as for instance, Dr James A. Harrar who on reviewing 91 600 confinements at the old Lying In Hospital in New York City found that there had been 59 instances of spina bifida of all types among them, and that nine others had been referred to them for care Concerning these 68 cases he reported

7 infants were stillborn

30 infants were treated without operation—all dying within a few weeks

31 infants were subjected to radical operation

Of the 31 operative cases 18 died within 1 to 21 days of meningitis encephalitis and so forth Nine died later of increasing hydrocephalus and inanition Of the remaining four healed operative cases two were discharged with increasing hydrocephalus and spastically paralyzed legs At the time of Dr Harrar s investigation 1 was 2½ years old—a help-

less hydrocephalic idiot with spastic legs One was living and well at the age of three years, having been operated upon at the fourth week for a simple meningocele.

Greisfwald and Denuce* have found that in infants not operated upon, the mortality is almost 100 per cent They report that of a total of 647 infants not operated upon in England 615 died before the end of their first year



Fig. 171 Photograph showing skin flap sutured around the excised edges of the ulcerated area and the stay suture fixing the upper skin flap. *(Campos technic)*

Because of the high mortality among infants suffering from spina bifida, due to infections during the first 15 days of life, and because of the fact that all previously described dressings for avoiding infection have failed, the report of Oswaldo Pinheiro Campos of Rio de Janeiro, is especially interesting Dr Campos reports his success with a dressing made of an autoplastic skin graft, and gives his technic as follows

Campos Technic The cystic bag is cleansed with a non irritating substance and the edges of the ulceration are incised The sac is punc

* Campos, O P., "Skin Graft for Spina Bifida with Meningocele or Myelomeningocele, J Internat. Coll. Surgeons 3 438 October 1940

tured and aspirated to relieve the liquid tension An elliptical (arci form) incision is made above the tumor, leaving about 5 *mm* of *skin* around the pedicle A second incision is made parallel to the first to form a skin flap (it is best to include the superficial fascia) of the same width as the ulcerated area to be protected The skin flap is then sutured to the borders of the skin of the tumor with great care being taken to



Fig. 172. Photograph showing the aspect after healing. The former ulcerated cystic bag is now transformed into a sac covered with normal thick skin, and is free of danger of rupture and consequent infection. *(Campos technic)*

close the angles A stay suture brings down and fixes the upper lumbar skin to the fibrotic pedicle of the herniated tumor The upper lumbar flap is finally sutured to the inferior border of the first incision left for this purpose, with a rim of approximately 5 mm

An occlusive dressing finishes up this simple procedure. Postoperative complications experienced with other methods such as infection, leakage *of spinal fluid and increase of intracranial pressure* have never been encountered with the protective autoplastic skin graft operation

It is advisable to bring the infant to the hospital for the operation if delivery occurs at home and to send him home as soon as possible For

various reasons, the mortality is less at home than in the hospital during convalescence, because of the constant care available which is usually impossible in a general hospital

The postoperative care consists of not permitting the dressing to become wet and keeping the infant s head lower than his body Twelve infants have been operated upon each developing a hydrocephalus which proves that this complication is not the result of the excision of



Fig. 173. Spina bifida in male child, aged nine months lateral view

the cystic bag but that hydrocephalus and spina bifida with myelomenin gocele are co-existing cerebrospinal malformations and that hydroceph alus does not develop as a consequence of the operative excision of the cystic bag

In conclusion, it may be said that although occasional surgical cures for spina bifida are on record the best that can be expected no matter what the treatment is very little at the present time

Spina Bifida Occulta

The usual location for spina bifida occulta is in the lumbar, the sacro-lumbar or the dorsolumbar regions It is a relatively unimportant and simple variety of spina bifida The lesion is usually represented by a small scar or depression often pigmented and exhibiting hypertrochosis

The bony defect in spina bifida occulta varies in size Sometimes it is exceedingly small and its presence is so counteracted by the membrane that no protrusion occurs. The pain which sometimes accompanies this condition is due to the pressure by a firm band of connective tissues joining the skin over the cleft at the lower end of the spinal cord which thus may cause anesthesia and hyperesthesia of the lower trunk and legs, as well as insufficiency of the bladder and rectum.

Treatment As a rule treatment is uncalled for in cases of spina bifida occulta. However, when there is much pain accompanying this condition, the constricting band mentioned above, should be severed. The indications for operation are here sharply defined

In those cases in which the bone deficiency is marked, resulting in pain and weakness, a bone graft inserted into the spinous processes above and below the defect (in the manner of the Albee operation for Pott s disease) offers the best means of strengthening and supporting the defective vertebra.

SYNOSTEOSIS OF VERTEBRA

The only anomaly of this group of any clinical significance is the so-called *sacralization of the last lumbar or fifth lumbar vertebra* Similar synosteosis of adjacent vertebrae in the lumbar and dorsal regions have been reported but these instances are usually of no clinical significance

Sacralization, and particularly when there is fusion of the transverse process of one side of the fifth lumbar vertebra has been listed as one of the possible causes of congenital scoliosis and low back pain

Treatment Enlargement of the transverse process is commonly observed in patients who have no symptoms *The association of this anomaly* with low back pain or complaint is not in itself an indication for

excision, and particularly not when a coexistant, pathological lesion such as arthritis is also present Excision should be limited to those patients who have radiating pain, sciatic scoliosis and negative roentgenologic findings, together with the physical manifestations which indicate that the sacralized transverse process is probably the offending cause If there is a pseudoarthrosis with definite arthritic changes at the



Fig. 174. R. R. No. 45413. Fusion and malformation of cervical vertebrae in a case of Klippel-Feil syndrome. *(From Elsberg Surgical Diseases of the Spinal Cord. Paul B. Hoeber New York.)*

point of antithesis of the transverse process upon the ilium or sacrum, relief is much more likely

The fusing of the lumbosacral or sacroiliac joint by operation has provided relief in many of these cases and it is a much less shocking operation than a transversectomy

Moore in 1923 reported a few cases in which patients with enlarged transverse processes in contact with either the sacrum or the ilium and associated with sciatic pain were relieved of symptoms within a period of two weeks following transversectomies

There are likewise many other references throughout medical litera



Fig. 175. R. R. No 43589 Deformity and fusion of cervical vertebrae in a case of Klippel Feil syndrome. *(From Elsberg Surgical Diseases of the Spinal Cord Paul B Hoeber New York)*

ture to cases in which transversectomy has been performed with good results

Moore's Technic An incision about six inches long is made over the posterior crest of the ilium After subperiosteal stripping of the lumbar and gluteal muscles a segment of bone two inches long and one inch wide is excised from the ilium This provides excellent exposure and

also removes the portion of the ilium in contact with the transverse process The process is then denuded of soft tissues, freed from the fibrous cord which is usually found, and resected with an osteotome Care should be exercised to avoid injury to the lumbar nerve lying anterior to the transverse process

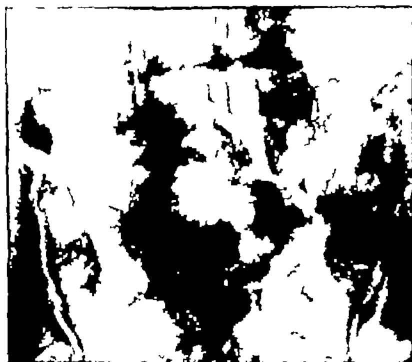


Fig. 176. Unilateral sacralization of the fifth lumbar vertebra with asymmetry of the body posterior defect in the arch and calcification of the iliolumbar ligament on the unsacralized side. The arch articulations at the lumbosacral joint are rudimentary at the fourth to fifth lumbar they are severely asymmetrical. *(From Roentgen Diagnosis of the Extremities and Spine by A B Ferguson—Paul B Hoeber Inc., 1941)*

After-Care Usually the patient may walk about after ten days or two weeks No immobilization is necessary

Putti and Scaglietti Technic for Transversectomy The patient is placed in the prone position in a manner which overcomes the normal lumbar lordosis An incision about 10 to 16 centimeters long is made slightly lateral to the midline from the second lumbar to the base of the fifth lumbar vertebra, thence continued obliquely downward and laterally for a distance of from four to six centimeters The erector spinae muscles are separated subperiosteally and retracted At the distal end of the

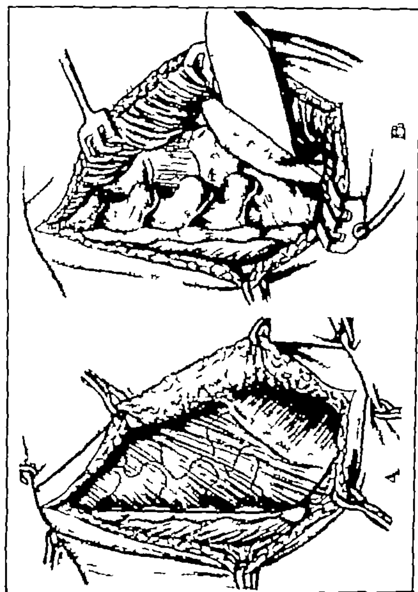


Fig. 177 Transversectomy for sacralization of fifth lumbar vertebra (Putti and Scaglietti) *A*, Exposure by skin incision slightly lateral to midline. *B* Retraction of erector spinae muscles and removal of portion of iliac crest. *(From Operative Orthopaedics by Willis C Campbell C. V. Mosby Co., 1939.)*

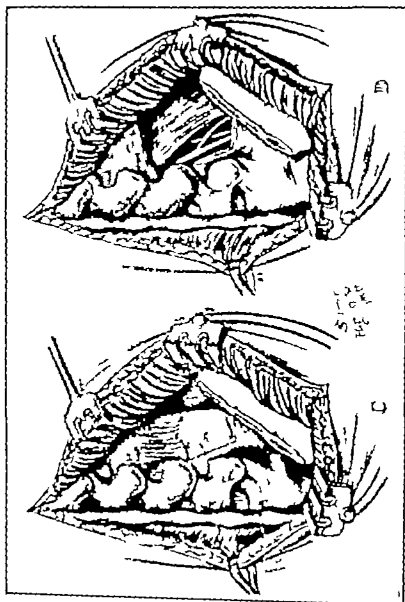


Fig. 178. Same as Fig. 177 C Sacralized transverse process exposed. Dotted line indicates amount of bone removed. D In removing sacralized transverse process and muscular fascia of iliopsoas, care must be exercised to prevent injury to lumbar nerves. (*From Operative Orthopaedics by Willis C Campbell*—C. V Mosby Co., 1939)

wound the iliac crest is exposed and a section four to five centimeters long and two to three centimeters wide is removed subperiosteally The fifth lumbar vertebra is located by palpation of the first free transverse process nearest the crest. The sacralized portion of the fifth transverse process is immediately distal to the free fourth process All muscular and tendon insertions to the fourth and fifth lumbar vertebrae are well freed, and the sacralized apophysis is removed with an osteotome. Extreme caution must be exercised in separating the apophysis at the sacrum to prevent injury to the lumbar nerves situated beneath the transverse processes

The resected portion of the crest of the ilium is replaced in its normal position and fixed with sutures Closure is followed by immobilization by means of a plaster cast for two or three months

TORTICOLLIS OR WRY NECK

Torticollis or wry neck may be either a congenital or acquired deformity It is characterized by lateral inclination of the head to the shoulder accompanied by torsion of the neck, and deviation of the face. Although permanent twisting of the neck is a symptom of many disassociated clinical conditions there are two main varieties of torticollis *congenital torticollis*, and *acquired torticollis*

Congenital Torticollis

Etiology Congenital torticollis is quite rare It may be present at birth or develop during the early months of life It may be hereditary and coexist with other congenital malformations It occurs more commonly in females than in males Many cases of wry neck frequently occur in association with difficult delivery occasioned by dystocia from malpositions and malpresentations of the fetus necessitating forceps delivery The characteristic lesion of torticollis is almost always limited to the sternocleidomastoid muscle

There have been theories promulgated as to the etiology of this condition but most of these have failed to present conclusive evidence. The most plausible theory to date is the one of ischemia. According to this theory congenital wry neck is analogous to the ischemic paralysis, with

degeneration of muscle fibers from prolonged partial obstruction of the circulation, described by Volkmann The blood supply of the sternocleidomastoid muscle is such that it can readily be obstructed by certain positions of the head Certainly the pathology of this condition indicates this as the most plausible etiological explanation



Fig. 179 Brace apparatus for torticollis. (Sayre)

Feil has called attention to the occasional fusion of the atlas with the occiput as both a primary cause and a contributing factor in congenital torticollis Because of this possibility and other anomalies of the column he advises roentgenographic studies of the upper cervical spine before correction of the deformity by surgery on the soft tissues is attempted

Pathology In such cases, there is a sclerotic interstitial myositis, accompanied by waxy degeneration of the muscle fibers producing dense

induration and shortening of the affected muscle—usually the sterno-cleidomastoid muscle—and associated with it as a rule, there is con tracture of the cervical fascia and the platysma muscle.

Clinical Features Clinically, there is a lateral flexion of the head to the affected side, and a rotation of the face to the opposite side. The chin is elevated and thrust forward and the shoulder of the affected side

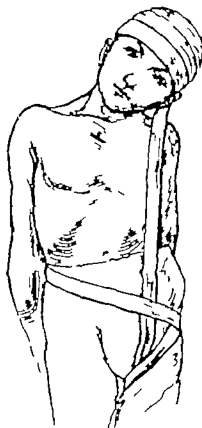


Fig. 180 Fixation dressing consisting of muslin bandage and adhesive to hold the head overcorrected after an operation for torticollis. *(From Orthopaedic and Reconstruction Surgery by F H Albee—W B Saunders Co., 1921)*

is raised The head as a whole is shifted toward the sound side. The affected muscle is more vertical than normal and feels hard on palpation, but is not tender to touch Secondary changes occur in the fascia and cervical spine. In the most chronic cases the platysma splenius and the scaleni muscles are shortened Lack of symmetry of the face and neck is noticeable but is most marked after the deformity has been corrected It may persist for several months or two or three years Usually it disappears gradually Lateral curvature and rotation of the cervical

spine, with or without compensatory curves is the rule This curvature may disappear after the cure of torticollis but if of long standing distortion most often persists

Treatment The treatment of this condition is of two kinds, *manipulative* and *operative*

Manipulative Treatment In the very mild case, repeated manipulation may check the progress of the deformity or cure the condition The

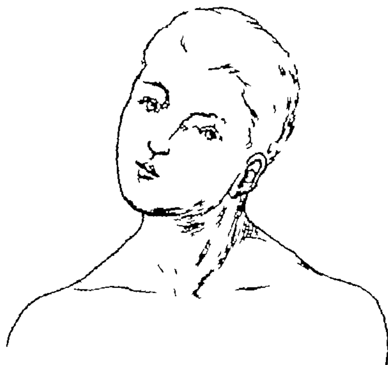


Fig. 181 Torticollis from shortening of the left sternocleidomastoid muscle which usually occurs from trauma at birth. The resulting obliquity of the eyes in the skull is very evident. *(From Orthopaedic and Reconstruction Surgery by F H Albee—W B. Saunders 1921)*

child s mother or an attendant is instructed to perform these *manipulations* as follows To flex the head to the opposite side, at the same time turning the chin to the affected side, and to repeat this manipulation several times a day (Such manipulations are best when given by a trained mechanotherapist.)

Operative Treatment To be successful any operation performed for torticollis must include the complete division of all tendinous, muscular and fascial bands which prevent derotation of the head, retention of the head in corrected position and postoperative correction of the

lateral curvature of the dorsal and cervical vertebrae. Subcutaneous tenotomy, which has been practiced, is not always successful and as it is accompanied by the grave danger of injury to important blood vessels and nerves, it is much less to be preferred than open operation

Open Operation Division of the sternocleidomastoid muscle may be performed in three places At the sternoclavicular end, at the mastoid end or at the center



Fig. 182. Same case as in Fig. 181 after myotomy of sternocleidomastoid muscle, and the application of the adhesive retention strap to hold the head in the overcorrected position. The drawing represents two adhesive straps of equal length fastened together by safety pins or sewing with their adhesive surface opposite to each other (*From Orthopaedic and Reconstruction Surgery by F H Albee—W B. Saunders Co 1921*)

1 *At the Sternoclavicular End* The muscle here is superficial and most easily reached Some surgeons divide the scalenus anticus also as it aids correction of the cervical scoliosis—but this procedure is rarely indicated Either an oblique or horizontal incision can be made. If horizontal it need be only 1 to 1½ inches long Oblique incisions along the

border of the muscle must be made longer The sheath is opened, and the tendons divided on a director from before backward, first the sternal, then the clavicular tendon of origin All fascial bands are picked up with forceps and severed Careful suturing of the wound must be done to avoid an unsightly scar

2 *At the Mastoid End* A curved incision extending from the mastoid backward into the scalp is made, and the muscle is stripped and separated from its bony attachments The advantage of this type of incision is that the scar is covered by a subsequent growth of hair

3 *At the Center* Division of the sternocleidomastoid muscle is performed by some surgeons at the middle point in the belief that there is less liability of the deformity to relapse because the separation of the cut ends is greater when this point of division is selected After division of the sternocleidomastoid muscle, kneading of the muscle must be performed, and simultaneously traction on the arm and head The head is then rotated away from the contracted side to aid in correcting scoliosis of the cervical spine and the shoulder of the affected side is depressed at the same time. The head is now fixed in its overcorrected position by a plaster of paris cuirass from the costal borders, around the neck, and over the vertex on the sides of the head, coming down on the forehead to the supraorbital ridges The cuirass is worn for from four to seven weeks and is then cut down and massage manipulations and appropriate muscle exercises instituted Forcible passive overcorrection of the head is performed twice a day One method of applying passive overcorrection is by self suspension in the sling used for applying plaster of paris jackets.

If the deformity tends to return, some form of apparatus must be worn, and a jury mast incorporated in the plaster jacket is useful, or a Bratz or Sayre s apparatus may be used The latter consists of a shoulder ring on the sound side, and a filet for the forehead Between the two extends a strong elastic band which can be shortened gradually to overcorrect the deformity In the simpler cases of wry neck, the authors use a band of adhesive two inches wide and pass this over the side of the face, in front of the ear and chin and onto the back thus holding the head in an overcorrected position with the chin pointing to the opposite shoulder In the severer type of case where structural changes

have occurred in the cervical spine, and there is shortening of the soft tissue structures which cannot be approached surgically, the head is held in a plaster of paris Minerva jacket—the plaster being molded over the frontal, occipital, and mental regions of the head, over the shoulder, and reaching well onto the thorax This jacket should be worn for a period of from two to three months and if there is still a tendency for



Fig. 183. Posterior torticollis.

the deformity to relapse, a similar plaster of paris Minerva jacket is reapplied and a brace subsequently worn in persistent cases Recurrence of this deformity is due either to incomplete operation, or to insufficient aftertreatment, and is therefore avoidable Postoperative massage and manipulative overstretching of the structures of the neck are quite essential in the convalescent postoperative treatment of most types of torticollis, and in my opinion, cannot be overstressed

Congenital Posterior Torticollis

This is much less common than the anterior form. The commonest cause is contraction of the trapezius and levator anguli scapulae muscle, with frequent complicity of the deeper muscles—the complexus, the

splenius and the trachelomastoid Section of these muscles is very diffi cult Stretching under anesthesia, and maintaining the correction by plaster of paris jacket or other apparatus, may be tried before operative intervention

Acquired Torticollis

In brief, acquired torticollis may be of three varieties, subdivided as follows

1 *Acute*
 (*a*) Myositis of the cervical muscles, ordinary stiff neck
 (*b*) Secondary to suppurating glands of the neck, or to angina
2 *Subacute*
 Due to glands of the neck, tonsils, measles, diphtheria
3 *Chronic*
 Caused by
 (*a*) Trauma (dislocation)
 (*b*) Cicatrices of skin and muscles
 (*c*) Reflex irritation from caries of the spine, such as Pott s disease
 (*d*) Scoliosis.
 (*e*) Brachial plexus neuralgia.
 (*f*) Occupation (frequent repeated movements of the head from side to side)
 (*g*) Rickets
 (*h*) *Paralysis of the spinal accessory nerves*
 (*i*) Psychic conditions
 (*j*) Spasmodic conditions
 (*k*) Anterior poliomyelitis
 (*l*) Meningitis (cervical opisthotomos)

Acute Torticollis. *Etiology* This is the most frequent of the acquired forms and is the most important variety from the standpoint of perma nent distortion The simple form is due to direct irritations of the muscle from injury and perimuscular inflammations combined with irritation of the peripheral nerve causing reflex contraction of the muscle In chil dren simple acute torticollis often begins with fever and malaise the muscle is tender to pressure and movement. The distortion is necessary

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Fig. 183 Posterior torticollis.

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   Caused by
   (*a*) Trauma (dislocation)
   (*b*) Cicatrices of skin and muscles
   (*c*) Reflex irritation from caries of the spine, such as Pott s disease
   (*d*) Scoliosis
   (*e*) Brachial plexus neuralgia.
   (*f*) Occupation (frequent repeated movements of the head from side to side)
   (*g*) Rickets
   (*h*) Paralysis of the spinal accessory nerves
   (*i*) Psychic conditions
   (*j*) Spasmodic conditions
   (*k*) Anterior poliomyelitis
   (*l*) Meningitis (cervical opisthotomos)

Acute Torticollis. *Etiology* This is the most frequent of the acquired forms and is the most important variety from the standpoint of permanent distortion The simple form is due to direct irritations of the muscle from injury and perimuscular inflammations, combined with irritation of the peripheral nerve causing reflex contraction of the muscle. In children, simple acute torticollis often begins with fever and malaise the muscle is tender to pressure and movement The distortion is necessary

to relax the inflamed muscles, and the deformity usually disappears when inflammation subsides Torticollis may be spastic from irritation of the branches of the spinal accessory nerve in the course of tonsillitis, pharyngitis, diphtheria, and other affections of the nasopharynx Spastic torticollis may also be occasionally hysterical in persons who are subject to nervous instability

Symptoms The onset is sudden and febrile. The contraction may involve several muscles namely the sternocleidomastoid, the trapezius, the posterior group of cervical muscles, etc. The muscle is tender to touch and to movement of the head Neuralgic pains in the neighborhood are common The duration is usually short, but when a local inflammatory process is persistently found, it may result from structural changes of the muscles and fasciae The muscles often undergo atrophy and degeneration

Diagnosis The commonest error is confusion with Pott s disease. However in acute torticollis, the onset is sudden without preceding stiffness and with neuralgic pain The movements of the head are restricted only when the inflamed muscle is put on the stretch All other movements are unrestricted In Pott s disease however the chin is frequently pointed toward the side to which the head is inclined traction of the head relieves pain instead of increasing it as is the case in acute torticollis reflex spasm limits motion in all directions

Arthritis of the atlo-axoid joint is also sudden in onset but in this condition all muscles of the neck are affected by spasm rather than only a single group as is the case in acute torticollis

Treatment Acute torticollis in its mildest form can usually be cured by the local application of heat and the use of a collar made of sheet wadding cardboard, and adhesive for maintaining the head in the proper position In the spastic types it is best to remove the cause of irritation and to treat the general condition of the patient The most urgent requirement is to relieve the tension of the muscle. For this purpose some sort of a collar such as just described is usually insufficient and it is probably best in most instances to use a jury mast incorporated in a plaster of paris jacket until the acute symptoms have subsided when exercise massage and manipulation can be started In cases of long standing anesthesia and forcible correction may be necessary followed

by the use of a jury mast incorporated in a plaster of paris jacket to maintain the correct position

Chronic Torticollis Of the various forms of chronic torticollis enumerated above only one requires special attention namely, spasmodic torticollis This affection bears no relation to the acute torticollis from affections of the peripheral nerves just described Spasmodic torticollis is a convulsive spasm of the muscles of the neck, in a general way similar to the phenomenon known as writer s cramp It occurs almost always in adults. Clinically the onset is gradual Initial symptoms are stiffness and discomfort of the muscles of the neck, with twitching or slight contraction pulling the head toward one side Gradually the characteristic attitude of torticollis is assumed, but the patient in the early stages of the affection can correct the attitude voluntarily and stop the twitching by holding the head Eventually, however, the spasm is uncontrollable and may also involve the muscles of the face and even those of the chest The spasm is increased by excitement or the execution of sudden movements, and is usually accompanied by neuralgic pain in the head and neck.

Etiology The cause of this type of torticollis is not known definitely Not infrequently there is a neurotic family or personal history Overwork, nervous shock, etc are also predisposing causes and constrained position of the head in certain occupations and eye strain from defective vision, suggesting the analogy to writer s cramp The hypertrophy and shortening of the affected muscle are both compensatory

Treatment It is of the utmost importance that the general condition of the patient be given close attention. If the patient is of the hysterical or neurotic type, psychotherapy may effect a cure, while if the condition is of occupational origin changes of work should be tried In early cases massage muscular exercises and a mechanical support are of aid in the treatment. However in many chronic cases, certain cure is offered only by operative procedure such as resection of the nerve innervating the affected muscles if the sternocleidomastoid and trapezius resection of the spinal accessory or resection of the posterior branches of the upper cervical nerves with division of the contracted muscles if other muscles are affected or deformity recurs after division of the spinal accessory The spinal accessory nerve may be exposed at a point one to two inches below the tip of the mastoid. The posterior branches of the upper cervi

cal nerves may be exposed by an incision downward from the occiput parallel with the spinous processes of the cervical vertebrae. After division of the complexus these nerves are exposed and the branches of the three upper nerves are resected

The tendency in recent years has been to limit the operations for the relief of this condition to three different procedures

1 Division of both the anterior and posterior spinal roots and spinal accessory nerves on both sides

2 Division of the first (there may be no posterior root), second and third cervical posterior spinal roots bilaterally, and division of the spinal accessory nerve on one or both sides

3 Division of the three upper anterior spinal roots and the spinal accessory nerves

In the authors opinion, the second of these procedures is the most preferable If as some writers have suggested, time proves it is only necessary to divide the anterior roots this would become a still more desirable procedure, as it would entail less loss of cutaneous sensation.

Paralysis following these operations is usually of no practical importance as the head can invariably be held in its correct erect position

Vertebral Deformities With Malformation of Other Parts

ABNORMALITIES OF THE CLAVICLE

Defects of the clavicle such as partial absence, have been noted These are usually associated with peculiarities of the cranial bone the palate the teeth, etc The clinical features are the slight drooping and the falling forward of the shoulders The shoulders can sometimes be approximated to actual contact by the use of a little force

FUSION OF THE RIBS

Defects of the ribs such as fusion of two or more ribs or faulty rib development have been reported but are of little practical importance



Fig. 184 Numerous congenital anomalies in the spine. Failure of union of ossification centers produces double hemivertebrae. Absence of centers causes hemivertebrae and absence of ribs. Failure of segmentation results in fusion of ribs and various degrees of fusion of vertebrae. All bones appear healthy Lines of division are clear-cut cartilage lines. *(From Roentgen Diagnosis of The Extremities and Spine by A B Ferguson—Paul B Hoeber Inc 1941)*

aided by cautious use of the knife The proximity of the pleura must be borne in mind and care must be taken to avoid injuring it. It is best to excise the rib extraperiosteally After exposing and developing a small portion of the rib it is followed to its spinal origin and there amputated with bone forceps and the stump carefully rounded off with rongeur forceps to avoid leaving a protruding spicule of bone The anterior attachment of the rib is then divided, and the rib removed. After all the bleeding points have been checked, the deep and superficial wounds are closed

Operation from Behind An incision is made beginning ¾ inch lateral to the spinous processes of the vertebra and a hand s breadth above the vertebra prominens and thence downward parallel with the spinous processes to a hand s breadth below the vertebra prominens After the trapezius has been divided, the serratus posticus and the splenius and the fibers of the complexus and the semispinalis colli are separated exposing the transverse processes of the two lower cervical and the two upper thoracic vertebrae and the junction of the cervical rib with the transverse process of the seventh cervical vertebra. The transverse process is then removed with bone forceps bringing the thin neck of the rib into view A curved periosteal elevator or other guard is passed above the neck of the rib and the latter is divided, avoiding the nerve roots which lie just anterior to it. With the rib held in lion jaw or other strong forceps it is developed by sharp and blunt dissection as far as possible. If the anterior connection is too firm to be broken sufficiently to permit of removal of the rib an anterior incision (as just described) is made, and the rib is removed in that manner

SPONDYLOLISTHESIS AND PRESPONDYLOLISTHESIS

The term *spondylolisthesis* is derived from the Greek and means a gliding of the vertebra and is applied to a forward subluxation of the body of the fourth or fifth lumbar vertebra, together with a superimposed vertebral column upon the vertebra below it, or upon the sacrum. The lesion is caused by a lack of fusion of the ossification centers which form the posterior and anterior halves of the neural arch Normally fusion takes place at a point between the inferior and superior articular processes. Usually the inferior articular process of the fifth lumbar vertebra prevents

forward subluxation of this vertebra upon the sacrum In spondylolisthesis and prespondylolisthesis however, the inferior articular process is attached only to the posterior segment of the neural arch of the vertebra and is thus unable to perform its function sufficiently

Any destructive lesion of the neural arch may result in spondylolisthesis Moreover defects in the neural arch frequently present no symp-

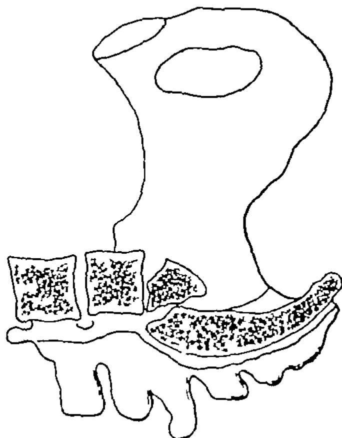


Fig. 186. Spondylolisthesis produced by fracture of the upper segment of the sacrum and its dislocation forward and downward. *(From Orthopaedic and Reconstruction Surgery by F H Albee—W B Saunders Co Philadelphia and London, 1921)*

toms and are discovered only by accident, as when a roentgenogram is made for another purpose, or in cases of trauma superimposed upon a previously painless defect.

Mechanics of Production The amount of displacement varies from a very slight luxation to a dislocation so extensive that the fifth lumbar vertebra slips forward and downward through a distance of 90 degrees until its normally inferior surface is opposed to the anterior surface of

Fig. 187 A.

Fig. 187 B

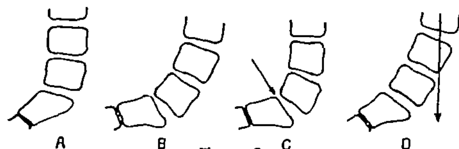


Fig. 187-C.

Fig. 187 A, A stable lumbosacral angle measuring 34 degrees. Fig. 187 B An unstable lumbosacral angle measuring 50 degrees. Fig. 187-C, A diagram of the stable and unstable arrangements at the lumbosacral angle. In *A* the bones are arranged in firm balance They may remain erect without the aid of muscles or ligaments. They would form a stable lumbosacral angle. In *B* the bones are in an arrangement which would collapse without the support offered by muscles and ligaments. The arch articulations could not prevent collapse. These bones would form an unstable lumbosacral angle. They present two elements of a weak nature which may exist together as in *B* or separately as in *C* and *D* The first element of weakness is that the weight-bearing plane of the sacral surface approaches too near the vertical, as in *B* and *C* The second element of weakness is that the line of weight thrust as represented by a vertical line through the center of the body of the third lumbar vertebra may pass far in front of the sacrum as in *B* and *D* *(From Roentgen Diagnosis of the Extremities and Spine by A. B. Ferguson—P B Hoeber Inc., 1941)*

the first, or first and second, sacral segments, with subsequent synosteosis in this position Thus the normal anterior surface of the fifth lumbar vertebra faces downward, and the articulation between the fourth and fifth lumbar spaces replaces the normal lumbosacral angle This causes more or less blocking of the pelvic inlet, tension upon the surrounding ligaments, fascia, and muscles, and probably pressure upon the spinal nerves or cauda equina The pedicles are thinned and elongated or actually severed, the laminae and spinous processes being forced backward The affected vertebral body becomes wedge-shaped its lower disc is absorbed, and it may fuse with the sacrum The sacral promontory is now replaced by the prominence of the fourth, third or second lumbar vertebra

Neugebauer makes the following classification of spondylolisthesis

1 Neural arches separated from the bodies
   (*a*) Defective development, congenital
   (*b*) Traumatic form from pressure
2 Change in the form of the vertebral body
   (*a*) From disease
   (*b*) From superimposed weight and pressure changes

(To this classification prespondylolisthesis or the pre slipped stage, should also be added)

Clinical Features Displacement of the spinal column downward and forward, with consequent forward displacement of the whole trunk, is the distinctive feature. In compensation for this the pelvic inclination is decreased, so that the symphysis pubis is on a level with the first sacral segment, or even on a higher plane. These changes result in a vertical shortening of the entire trunk in the abdominal region which is strikingly evident in the front view on account of the high position of the symphysis pubis Diminished inclination of the pelvis causes broadening and flattening of the gluteal region and prominence of the posterior inferior iliac spine. The iliac crests stand out sharply from the loins This condition has been adequately named saddle back —the lumbar region and loins appearing to fall away The buttocks are small and the posterior pelvic outline is quadrilateral

The lumbar lordosis diminution of the pelvic inclination and vertical shortening of the trunk are almost pathognomonic of spondylolisthesis

when combined with the detection of the marked angularity between sacrum and lumbar vertebrae on vaginal, rectal, and roentgen examinations Associated with these changes are partial flexion of the hips, knees, and ankles when the patient stands

Low back pain, exaggerated by standing posture, is the most prominent symptom of spondylolisthesis The slipping forward of the lumbar vertebrae on the sacrum alters the entire line of weight bearing of the spinal column, and because of this faulty position, the muscles, fascia, and ligaments are subjected to constant stress, often giving rise to constant pain in the lower back when the patient is standing

Recently several authors have suggested that herniation of the nucleus pulposus or slipped disc, causing pressure on the spinal nerves or cauda equina, is common in spondylolisthesis, and it is thought that this is a chief cause of the sciatica associated with spondylolisthesis Meyerding recommends that all cases of spondylolisthesis complaining of low back pain with sciatica be given the advantage of orthopedic, neurologic, and roentgenologic opinions and suggests that better results are obtained when the treatment consists of the combined laminectomy and fusion procedure However, the authors have found that fusion of the third, fourth and fifth lumbar vertebrae to the sacrum by a strong tibial bone graft is sufficient in the large majority of cases

Treatment The treatment of this condition is almost entirely mechanical, since the painful symptoms are due to vertebral displacement, resulting in overstretching and undue tension upon the ligaments surrounding the vertebra Usually the longer the patient is on his feet, the more severe the low back pain

Until the introduction of the immobilizing spine operation no satisfactory treatment had ever been devised for this important condition which is not controllable by splinting methods

Braces or a plaster jacket, affording neither relief nor cure have proven of little value for the reason that the only counter pressure that can possibly be effective in such a condition must come anteriorly in order to exert influence on the anterior surface of the displaced vertebral bodies and obviously it is impossible to exert sufficient pressure through the abdominal cavity to produce adequate immobilization



Fig. 188-A. Case of spondylolisthesis in a woman 32 years of age—one and one-half years after fusion attempted by Hibbs technic met with failure. Arrows indicate no fusion at proposed fusion area. Spinous processes of the third, fourth and fifth lumbar vertebrae completely absent.



Fig. 188-B. This is the same case as Fig. 188-A, and shows the strong tibial inlay graft morticed into the spinous processes of the second lumbar vertebra, and coapted onto stumps left by the Hibbs operation of the third, fourth, and fifth lumbar vertebrae as well as the sacrum.



Fig. 188-C. Anteroposterior view of the same case as Fig. 188-A and Fig. 188-B.

The bone graft, and especially with the mechanical features it offers, as applied by the authors, is especially well adapted to the difficult problem of immobilizing the spine, in that a strong graft inlaid into the exceedingly strong spinous processes of the lower lumbar vertebrae and carefully coapted onto the posterior surface of the sacrum affords a very firm immobilization, particularly as the large spinous processes of the third, fourth and fifth lumbar vertebrae provide unusually firm anchorage for the graft, since the stress upon the graft comes in an anterior direction The tendency of the old deformity to relapse, and of the lower vertebrae to sag forward, only forces the lower end of the graft more firmly against the posterior surface of the sacrum when the graft has grown firmly into the spinous processes of the vertebrae Therefore there is not the same necessity for anchoring the inlay firmly to the sacrum as there is in the case of the vertebrae The graft must always be anchored to the spinous processes of at least two vertebrae above and below the displacement. If the displacement is between the fourth and fifth lumbar vertebrae, the graft should be inserted to the spinous processes of the third and fourth *lumbar vertebrae which lie above the displacement and to the* fifth vertebra and the sacrum which lie below it.

Albee Technic of Operation The spinous processes of the lower lumbar vertebrae and the posterior part of the sacrum are exposed by means of an incision, curving slightly to the right side, and turning up a flap consisting of thin soft parts down to the superficial fascia. The supraspinous and interspinous ligaments are split by means of a scalpel passing over the central portion of the tips of the spinous processes and in between them. The small spinous processes on the posterior surface of the sacrum are likewise located and the ligamentous structures split over their tips in the same manner With a broad sharp 1½ inch osteotome, the spinous processes of the lumbar vertebrae are split longitudinally as near to their centers as possible care being taken not to fracture the halves of the spinous processes opposite the operator the latter standing on the left side of the patient The portion of the spinous processes on the side of the operator is forced laterally toward him and may be in more than one fragment but as these fragments are embedded in the firm interspinous ligament, no disadvantage is entailed The small spinous processes of the upper two segments of the sacrum are treated likewise and their

left halves displaced sufficiently with their embedding ligaments to allow a graft the full thickness of the tibial cortex to be inserted between them

After the spinous processes have been split shavings and particles of bone are turned toward each other This is done to add additional osteogenic material and influence to the graft when inserted With an osteotome and curette, the posterior area of the sacrum with which the graft is to be coapted is thoroughly scarified

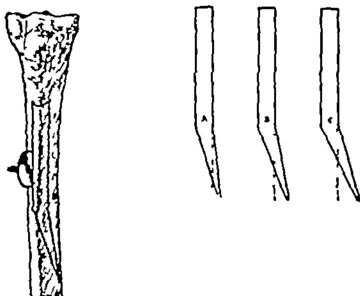


Fig. 189 Diagram showing contour of graft as it is being removed with motor saw from the antero-internal surface and crest of the tibia. *A B* and *C* variations in the lower or sacral portion of the graft in accordance with the obliquity found between the posterior surface of the sacrum and general allignment of the lumbar spine. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York.)*

Next, by means of a flexible probe, the entire contour of the proposed graft is obtained Care must be taken to get an accurate pattern of the posterior part of the sacrum and its angulation with the general axis of the lumbar column.

The spinal wound is then packed with hot saline compresses and the antero-internal surface of the central portion of the left tibia is laid bare by an incision over the crest. With the molded probe as the pattern, the proposed graft is carefully mapped out on the anteromedian surface of the tibia by means of strokes of the scalpel in the periosteum The sacral end of the graft will have a sort of goose neck projection for insertion into

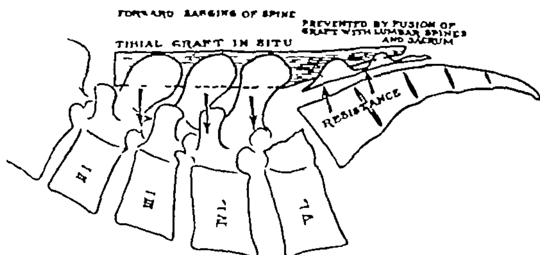


Fig. 190-A.



Fig. 190-B.

Fig. 190-A, tracing of x ray picture eight months after operation. This tracing shows the conformation of the graft, and its position in the spinous processes of the lumbar vertebrae and insertion into the posterior surface of the sacrum. The arrows indicate the direction of forces which are exerted upon the graft as a result of its immobilizing influence. Fig. 190-B, Fusion of spine in a case of spondylolisthesis showing tibial bone graft, BG immobilizing lumbosacral spine. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company)*

the posterior shell of the sacrum at about the third segment As it is desirable to have the sacral end of the graft stronger, this will be the inferior end because the cortex in the lower end of the tibia is thicker than that in the upper end



Fig. 191 Lumbosacral fusion by posterior bone graft (Albee method) in a case of low back pain due to congenital non-union of laminae and spinous process—so-called prespondylolisthesis. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

A recent innovation of the senior author is the shaping of a hook at the end of the graft so as to insure a firmer anchorage into the sacrum.

The graft is inserted into the bed prepared for it in the lumbar vertebrae and sacrum. A hole large enough to receive the goose neck projection of the graft, is then made in the thin posterior sacral shell with a narrow osteotome By means of the bone set and mallet it is firmly seated par

ticularly onto and into the sacrum, force being exerted to overcome as much as possible of the spondylolisthetic displacement The deformity is further corrected by the tension of the strong kangaroo sutures which are

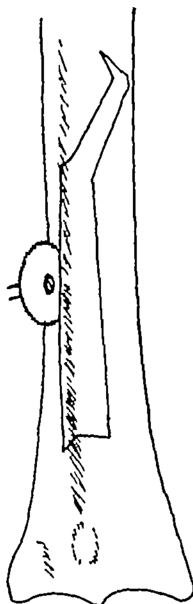


Fig. 192. A schema showing senior author's recent innovation in shaping a hook at the end of graft which insures a firmer anchorage of the graft into the sacrum.

used to immobilize the graft thoroughly in the firm ligamentous structures of the lumbar spine and sacrum.

After the back and leg wounds have been closed generous dressings of gauze and absorbent cotton are applied that over the spinal wound being particularly large

The patient is then placed in the dorsal position upon a fracture mattress Here he should remain for seven weeks A low corset brace with a surcingle around the lower end is then applied This is worn for from four to six months

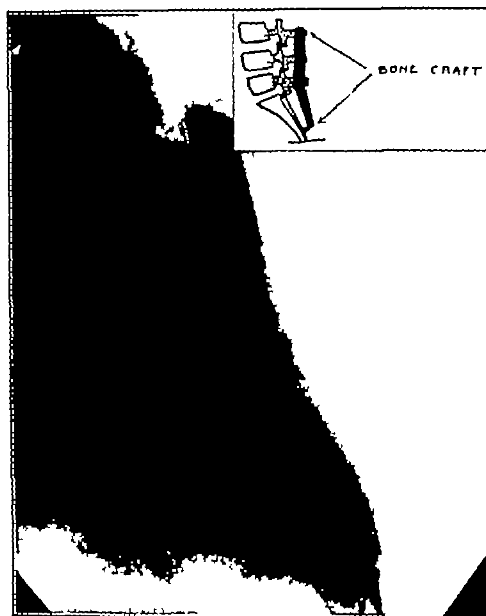


Fig. 193 Lateral view of lumbosacral spine following bone graft fusion. Note angulation of graft to conform with sacral contours at its midpoint and kink at lower end to insure firm anchorage into sacrum.

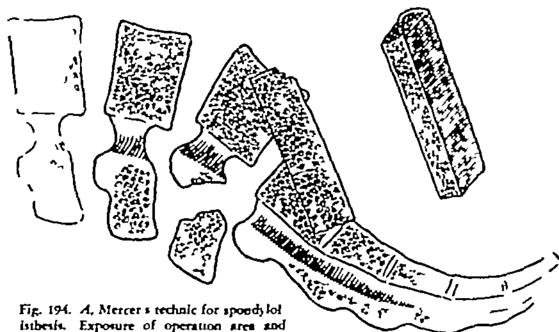
Mercer's Technic The patient is placed upon his back on the table in an exaggerated Trendelenburg position A midline incision is made extending from the pubis to just above the umbilicus The contents of



A



B



C

Fig. 194. *A*, Mercer's technic for spondylolisthesis. Exposure of operation area and emplacement for graft. *B* grafts being placed in position. *C* area suggested for graft. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

the abdomen are then packed off from the area of operation by the insertion of a self retaining retractor Inspection of the subluxated vertebra is now made and its relation to the iliac vessels determined The posterior peritoneum is now divided so as to expose the gap between the sacrum and the slipping vertebral body After ligation of all bleeding vessels, an osteotome is driven in an anteroposterior direction into the lower margin of the fifth lumbar vertebra ⅛ inch from its lower edge and into the sacrum, ⅛ inch from its upper edge Thus a rectangular hole is produced after the pieces of the bone and the intervertebral disc have been resected Two pieces of bone are taken from the crest of the ilium, since a single piece cannot be obtained broad enough to wedge in firmly The grafts are hammered tightly into the gap between the sacrum and the fifth lumbar vertebra and then are further screwed into place to insure their retention. Failure to screw such grafts into place has resulted in the opening of the lumbosacral gap and the springing out of the wedges of bone when the patient is lifted off the table. Further to avoid this, the patient is usually operated upon while lying in a posterior plaster shell

After Care The patient remains in the shell for four months lies free from restraint in bed for one month and thereafter is allowed up in a Goldthwait brace

Speed's Technic Depending upon the duration of the condition and the roentgenological findings, an attempt is sometimes made to overcome some of the displacement of the fifth lumbar vertebra by means of suspension traction in bed before operation is undertaken.

A midline abdominal incision extending from the umbilicus to the pubis, makes for ample exposure of the sacral promontory after the patient is tilted back and the intestines are packed away By palpation the relation of the fifth lumbar vertebra and the sacrum is determined and roentgenologic findings confirmed If the aortic bifurcation is low, it may along with the left common iliac vein be gently held back by a padded retractor

The peritoneum is now incised from the fourth interspace to the sacrum just to the right of the midline, the middle sacral artery and nerve and the ganglion of the sympathetic nerves being avoided After the amount of displacement and angulation have been ascertained a chisel is used to make an entrance into the vertebral bony mass at or below the level of

the fourth interspace The angle required to penetrate the body of the fifth lumbar vertebra and to enter the sacrum, is then decided.

As the patient lies supine, a large drill is inserted obliquely and nearly directly downward through the body of the fifth lumbar vertebra. The passage of the drill through the lower posterior body of the fifth lumbar vertebra and the intervertebral space is discernible by the sensations produced The length of the graft and the depth of the hole to be made by the drill, may be determined by measurement A bony transplant of the proper dimensions is then taken from the tibia and inserted into this hole. The subperitoneal tissue is closed with interrupted catgut, and the posterior peritoneum with a running stitch of catgut. The abdomen is closed in layers without drainage

After-Care The patient is placed on a moderately firm mattress or fracture bed, which permits proper nursing care without flexion of the back. After eight weeks of confinement in bed a spinal brace is fitted and the patient is allowed up The brace is used until there is roentgenologic evidence of bony fusion

The many technical difficulties of fusing the bodies of the fourth and fifth lumbar vertebrae from the front and the magnitude of the procedure, further increase the hazards and postoperative complications from operations of the Mercer and Speed type In contrast, the bone graft implantation posteriorly into the spinous processes is exposed to a more favorable stress insofar as the gravital force of the spine tends to increase the coaptation of the bone graft with the lumbar spine and sacrum, and thus constitutes a bone block to prevent further dislocation It also is a much less hazardous operation, and requires but a minimum of time for its performance

An operative method involving insertion of a graft from the dorsal side toward the vertebral body has been described by the Frenchmen, Lance and Aurrousseau and also by Mathieu and Demirleau The principle of the procedure of Lance and Aurrousseau is to chisel or saw off a graft from the posterior part of the iliac crest, leaving its posterior medial part united with the crest, and then to bring its lateral end toward the fourth and fifth lumbar transverse processes which have been split. The criticism here has been that the material used for the graft is poor

Mathieu and Demirleau describe a similar method of iliolumbar osteosynthesis for spondylolisthesis, in which they use a powerful graft taken from the tibia They bore a hole in the posterior part of the iliac crest and through it they put a tibial graft, bringing it into contact with the split transverse processes of the fourth lumbar vertebra

Both of these operations are done bilaterally and in successful cases a bilateral fixation of the slipping vertebral segment is obtained These operations however, are exceedingly difficult and unnecessarily complicated and do not meet the mechanical demands of the condition in a direct manner

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CHAPTER IX

Low Back Pain
And Affections of the Lower Back

To the profession the diagnosis and treatment of *low back pain* has always presented a most difficult problem. The many articles written on the subject especially during recent years, bear testimony to the widely divergent opinions as to the appropriate diagnosis and treatment required

In 1927 the senior author recognizing the difficulty of interpreting the underlying causes in each case, introduced the term myofascitis" for the purpose of assembling together under one clinical entity and thus standardizing the treatment of by far the largest group of those cases which had been diagnosed empirically and treated as lumbago sacroiliac sprain, sacroiliac relaxation, sciatica, strain of the lumbar muscles, bursitis rheumatism, acute lumbosacral angle, congenital anomalies variations in the spinal column sciatic scoliosis contusion low back pain, low backache, ruptured muscle fibers torn ligaments, spastic toxic pyriformis fascitis and contractures and more recently displaced intervertebral disc, rupture or herniation of the nucleus pulposus thickened ligamentum flava, and narrowed intervertebral spaces.

Though undoubtedly in the last analysis each of such diagnoses will be shown to be a contributing factor in the final determination of the true underlying causes of low back pain for the most part such terms merely describe a local or secondary manifestation and the physician s attention concentrated on such local or secondary manifestations usually deemed orthopedic in nature, has missed the underlying cause toxicity of the blood and faulty metabolism with localization in the muscles fascia and tendon insertions of the lower back

The senior author s term myofascitis is used to designate toxic inflammatory or metabolic changes of muscles and their associated fascia, with such local symptoms as those of the conditions just listed. As an inclusive

designation, covering the widely diversified manifestations and multiplicity of symptoms, most of which have a common origin it rationalizes treatment along one definite line instead of many, some based upon misconceptions, and so has become an entity in diagnostic nomenclature in recent years

Although the great majority (85 to 90 per cent) of cases of low back pain must be attributed to toxicity and faulty metabolism since they respond to continued conservative treatment for these conditions, there is no doubt but that there are many other true underlying causes Since Mixter and Barr published their first work on protrusion of the intervertebral disc as a cause of low back pain there has been a growing tendency toward laminectomy as a primary treatment The literature on this subject during the past few years has been tremendous and it is often suggested that the clinical picture is typical Many writers suggest that the diagnosis is easy and definite with or without lipiodol or air myelography and Dandy describes the concealed disc, although it is often difficult, or even impossible, to find the offending portion of the protruding nucleus pulposus at operation even following positive lipiodol or air myelography diagnosis

Before the nucleus pulposus of Schmörl was resurrected these cases would have been treated and should continue to be treated in a large measure as myofascitis, as the symptoms are indistinguishable from the low back pain due to this cause It is logical to assume that if protrusions of the intervertebral disc are common today from tears of the annulus fibrosus or from definite herniation of the nucleus pulposus they must have existed in the same proportion before the past few years bringing patients to the medical profession for relief operative or otherwise.

The authors have seen so many such cases relieved by prolonged conservative means without resort to any operative intervention that they advocate surgery that is fusion of the spine in the majority of instances only in selected cases with x ray evidence of pathology The authors do not doubt that pressure on the cord or nerve roots from a ruptured nucleus pulposus or thickened ligamentum flava may exist as a causative agent in the production of low back pain, but feel that this entity has been overemphasized, as most new procedures usually are, and that the condition is extremely rare Even following what is thought to be a positive diagnosis,

the symptoms may be relieved by conservative measures, and when an operation is considered necessary the symptoms are relieved, in a large percentage of cases * by fusion alone, without recourse to laminectomy

The symptoms of low back pain may be prominent in any of the following conditions each of which requires a separate discussion

1 Myofascitis.
2 Prespondylolisthesis and Spondylolisthesis
3 Arthritis
   (*a*) Osteo-arthritis
   (*b*) Rheumatoid.
4 Tuberculosis of the sacroiliac joint.
5 Tuberculosis of the spine.
6 Posterior protrusion of the intervertebral disc.
7 Anomalies of the spine
8 Thickened ligamentum flava.
9 Narrowed intervertebral space.
10 Ununited fractures
11 Spina bifida
12 Tumors
13 Defective balance
14 Gynecological conditions
15 Hysteria

Myofascitis

This is an anatomic and descriptive term indicating both general location and pathology The authors include in this group *all those conditions* with a common toxic or metabolic origin which have been masquerading under the designations previously discussed and thereby achieves the rationalization of treatment along one basic line for by far the largest *number of sufferers from* low back pain

Etiology and Pathogenesis. *Sex* Myofascitis is slightly more frequent in the male than in the female 57 per cent of the senior author s reported series of 1188 cases † being males

* Farrell, B P and MacCracken, W B., "Spine Fusion for Protruding Intervertebral Discs." Journal of Bone and Joint Surgery 23 457-460 (April) 1941
† Albee F H and Campos, O P Low Back Pain and Allied Conditions," Amer J of Surg 43 386, 1939

Age Myofascitis knows no age limit During 1939, the senior author reported cases of patients under three years of age, and over 80 The increase in frequency, up to the age of 50, is in direct proportion to the age, 25 per cent occurring between the ages of 20 and 30, 29 per cent between 30 and 40, and 39 per cent between the ages of 40 and 50

Trauma Trauma is of secondary importance, only aggravating a pre existing myofascitis or contributing to localization at a particular site in a group of muscles or fascia of the toxins which are being carried by the blood and lymphatic systems Even when considering as a causative accident the simple lifting of a light object trauma as a factor occurred in only 25 per cent of the Albee series In most cases the muscular effort of lifting is not considered as having any etiological relationship but merely as calling the patient s attention suddenly to the fact that his muscles are already sensitive. The explosive onset is usually due to a muscular or fascial adhesion giving way and is associated with local and violent muscle spasm

Infection The main underlying cause of myofascitis is focal infection. Focal infection of various types was found in 52 per cent of the Albee series of cases Infected teeth were found in 20 per cent, infections of the tonsils in seven per cent infections of the nose and sinuses in six per cent Other contributing factors were colds abscesses, osteomyelitis, gallbladder infection, colitis appendicitis lithiasis prostatitis, pyelitis cystitis mastoiditis, gastric ulcer gynecological conditions, tuberculosis and pyogenic pulmonary abscesses

Constipation This is another prominent toxic source and is a contributing factor in approximately 12 per cent of all cases of myofascitis As a guide to treatment it is very helpful to have stool examinations made in all cases in which metabolic etiology is suspected. The authors are convinced after studying hundreds of cases in which stool examinations have been made that histamine in large quantities in the colonic content is an index of the toxicity of the stool, whether it be the principal offending toxic agent or not. In seven per cent of the Albee series of cases the histamine index was found to be four or five plus above normal

Metabolic and Glandular Disturbances In conjunction with disturbances of metabolic origin glandular disturbances are also to be considered It has been recognized for many years that there is a relationship

between sciatica, lumbago, and other so-called rheumatic conditions, and gout In many cases of myofascitis, uric acid retention is found, and once this condition is corrected the symptoms disappear In seeking the etiology of all doubtful cases blood uric acid determination should be a part of the routine investigation Nervous strain leading to metabolic disturbances, is a frequent cause, and this was found to be a contributing factor in many cases during the recent depression

Allergy and Vitamin Deficiency There is increasing evidence that allergy plays an important role in the etiology of myofascitis due to the consequent metabolic disturbances or to some other unknown manifestations of the allergy Vitamin deficiency for the same reasons may also be a contributing factor

Pathology The pathology of myofascitis is not yet well known for the reason that in such cases necropsies and biopsies are seldom available Subcutaneous nodules have been found to contain a gelatinous substance with leukocytic infiltration Chronic inflammation of fasciae covering the muscles or nerves has been described Physicochemical alterations of the muscular fibers have been observed, and were described under the name of myogelosis by Schade In some cases, real histologic lesions in the form of round-cell infiltration have been detected by the authors and are so marked as to be considered evidence of a true myositis

Symptoms or Clinical Findings. *Inflammation* Manifestations of toxic involvement are usually of a low grade Indeed it is surprising that from an ordinary clinical examination more cannot be found in the way of edema or exudate as evidenced by the increase in diameters Occasionally in severe acute cases in very muscular individuals the hamstring muscles have been found to be extremely sensitive to palpation and with a series of knots extending from the tuberosity of the ischium to the popliteal area, necessitating constant recumbency However such acute manifestations are in the minority and are more apt to be seen by the physician—usually as lumbago—than the orthopedic surgeon The orthopedist usually does not see the case until the symptoms persist and become subacute or chronic. The orthopedic surgeon may be misled because he has not had the opportunity of [illegible] the beginning of th[illegible]
The physician seeing only th[illegible]
to follow the cases during la[illegible]

lacks a clear understanding of myofascitis (It must be understood, however, that not all cases begin acutely)

Pain Pain may be vague or definite, and related to the spine, sacrum, or posterior wing of the ilium The most frequent location of pain is the lower back and sacroiliac region where there are so many fascial insertions into the bone Constant functional tension on the muscles and fascia at the lumbar spine and ischial tuberosities accounts for the very troublesome and persistent symptoms in this region Other points of myofascial insertion, such as the patellae, the point at which the tendon Achilles is attached to the os calcis and the epicondyles of the humerus may also be sensitive to touch or tension, but the senior author found that in 54 per cent of his series, pain in the lower back predominates although other regions of the body may be involved simultaneously Other bodily regions are susceptible in the following order The lower extremities the upper extremities the neck the scalp, and the face muscles Why this condition should involve so universally the gluteal and hamstring muscles and particularly when it is unilateral why it should involve the left side in a ratio of 60 to 40 per cent, the authors have no explanation When the predominate pain is in the lower back, the pain may seem to be in the sacroiliac joint, but upon more careful study it is found to be more widely distributed in the surrounding muscular insertions particularly the pyriformis muscle, most of which originates in the capsule of the sacroiliac joint

Many of the patients referred to the authors, having previously complained of pain in the region of the sacroiliac joint had been treated or operated upon elsewhere for relaxation of this joint The diagnosis had been erroneously considered confirmed when immobilization methods such as strapping or application of a belt or a cast afforded temporary relief Adhesive strapping as usually applied for so-called sacroiliac relaxation immobilizes and relieves tension of the sensitive muscles and therefore gives relief Recurrence of symptoms and pain however was frequent, due to the fact that the primary etiological factor toxicity had been left untreated

Flexion of the hip associated with extension of the knee causes tension and resultant acute pain at the fascial insertion of the involved gluteal and hamstring muscles into the bony structures in the region overlying the sacroiliac joint. These fascial anchorages of muscles to

bone at the crossroads of the trunk and thighs, are pulled upon by the most powerful muscles of the body and are more or less in tension most of the time Therefore if sensitive from toxic irritation, constant pain and discomfort may result It is advisable, because of its constancy, to use the straight leg raising test when toxicity is suspected, even elsewhere, and if pain is elicited, in the opinion of the authors, this is the positive myofascitis or M F sign

So-called sacroiliac strain is associated with symptoms widely distributed outside the joint, a fact not consistent with simple joint strain It is practically impossible, because of the anatomic position of the joint beneath the posterior wing of the ilium and the deep overlying structures, to be certain whether the pain is from pressure on the joint itself or on the fascial insertions of the muscles into the surrounding bony structures A careful analysis of findings and symptoms leads one in many cases to the latter conclusion and the results of treatment based upon this conclusion, support it more definitely than any theoretical considerations If there is sensitiveness to deep pressure over the fascia or muscles in the region of the posterior superior spine of the ilium or the posterior surface of the sacrum or over the gluteal fascia, and along the fascia lata on the outer aspect of the thigh, the case is one of myofascitis rather than sacroiliac strain In certain instances this sensitiveness may extend from the outer side of the thigh to the region of the external malleolus

From repeated examinations the authors feel that true sciatica is also rare, and that most cases clinically called sciatica are myofascitis or a complication of it The character and wide distribution of sensitive areas noted on palpation is not in accordance with the location of the nerve trunk and its branches but rather with that of the fascia

Differential Diagnosis The distinguishing of myofascitis from other conditions having as their main symptoms low back pain is of great importance The necessity for a better understanding of this condition by the profession cannot be overestimated. It is of equal interest to the orthopedic surgeon the neurologist, the neurosurgeon the general practitioner or internist the gynecologist and even to the cardiologist

Rarely does one encounter a condition concerning whose diagnosis and treatment a greater diversity of opinion exists among eminent physicians So a careful differential diagnosis is of paramount importance before a

case should be labelled *myofascitis* Factors to be considered in such a diagnosis are a history of former manifestations of toxic absorption, such as headaches cricks in the neck and lumbago, and usually some evidence of a focus of infection or origin of toxic absorption such as an infected tooth tonsils, or colitis The presence or absence of these must be carefully determined by x ray findings and physical or laboratory examinations X rays, both anteroposterior and lateral must be taken of the lumbosacral spine Only when these are negative can the case be considered one of pure myofascitis

It is incredible the great number of sacroiliac fusion operations which have been performed for simple cases of myofascitis In recent years, fusion of the lumbosacral joint has also become very popular, and as could be expected the symptoms are frequently not relieved by such operations Myofascitis in the lumbosacral region results in pain in the region of the sacroiliac joint because of the tension upon the fascial and muscular insertions over or directly around it Adhesive strapping as usually carried out for sacroiliac relaxation or strain may relieve pain temporarily because the immobilization relieves the sensitive insertions of fascia and muscles *from the tension of muscle pull or postural change.* The reason spinal or sacroiliac fusion fails to relieve the symptoms in many instances is because of the fact that bony fusion does not often permanently and completely relieve the stress upon these muscular and fascial insertions

Many operations have been devised recently for the relief of pain in the lower back, such as the Ober Operation for instance in which the iliotibial band between the crest of the ilium and the greater trochanter is severed. Excision of the pyriformis muscle which was suggested by Barshinger in 1908 has also been attempted and laminectomy for the removal of pressure on the cord or nerve roots, from protruding intervertebral discs thickened ligamentum flava, etc. has also become very popular

The authors have been called upon to examine many patients upon whom such operations have been performed without result or for whom an operation has been recommended by one or more consultants In 283 case where an operation was recommended, and in 52 cases in which one or more fusion operations were performed elsewhere without relief

all improved immediately or were ultimately completely relieved when the correct diagnosis was made, and adequate treatment carried out. In those cases of myofascitis which are relieved by sacroiliac fusion, it is a question whether the relief is due to the fusion *per se*, or to the stripping of the muscle insertions from the overlying bony structures This was unexpectedly found to be true by Dr Percy Roberts who started to do a sacroiliac fusion for relaxation, but after the fascial insertions of the overlying muscles had been stripped from the bone, the patient went bad and operation was stopped and the sacroiliac was not operated on The relief, however was complete. Because of this Dr Roberts did other operations of this kind and reported approximately 15 other equally successful cases Some of these cases today would no doubt have been diagnosed as displaced intervertebral disc.

Myofascitis is prevalent in muscular individuals of a plethoric nature who have formerly been athletes but who at the time of the onset of symptoms, are leading sedentary lives The cause may be, to a degree occupational too sedentary a life leading to uric acid retention and toxic absorption. Myofascitis may be a pre arthritic condition, the authors records show that seven per cent of the old cases of myofascitis are complicated by arthritic changes of the spine A number of cases have been observed where there was no evidence of arthritis at the first examination but in whom at a later examination joint involvement was noted This was especially true of cases which had failed to undergo adequate treatment Symptoms of myofascitis are danger signals that arthritis is impending unless precautionary corrective measures are taken to ward it off Constant absorption of poisons into the circulation may result in arthritis, arteriosclerosis or some other condition more serious than myofascitis

Myofascitis and Neuritis Acute pyogenic infection of a nerve practically does not exist A nerve can remain free of any infection even when in contact with a pocket of pus and metastatic localizations in a nerve from a distant source of infection are unknown. Care should be exercised in making a diagnosis of neuritis of an individual nerve and reliance should not be placed upon tenderness to pressure over a certain point or pain involving the distribution of a nerve Myofascitis may result in identical spots of tenderness and identical underlying causes

Myofascitis and Prespondylolisthesis and Spondylolisthesis Careful x ray examination of the lumbosacral spine is essential for all patients suffering from low back pain The roentgenograms should include views in the anteroposterior, lateral and often oblique planes, and should be taken at the time of the first examination Low back pain is the commonest symptom of spondylolisthesis, and during recent years our attention has been drawn toward the cases presenting a prespondylolisthesis as these often present more severe symptoms than those with true spondylolisthesis There is usually a history of slight trauma, but on careful analysis it will be found that the patient often has suffered from slight pain in the lower back for many years It has been suggested that protrusion of the intervertebral disc is frequent in those cases with spondylolisthesis having an associated sciatica. When the symptoms persist laminectomy with spinal fusion is recommended by some as the best means of obtaining permanent relief, but the authors feel that laminectomy is necessary very rarely, and the results of fusion alone are just as satisfactory

Myofascitis and Arthritis Arthritis should always be suspected in patients with a long history of low back pain Myofascitis is undoubtedly a pre arthritic condition and approximately seven per cent of all cases of long standing present positive evidence of arthritic changes in the lumbosacral spine This is especially true of the untreated cases

Myofascitis and Cord or Nerve Root Symptoms from Protruding Intervertebral Discs etc The nucleus pulposus of Schmörl has recently been resurrected to play a too frequent and outstanding role as the cause of low back pain The authors feel certain that the entity is extremely rare, and that a large percentage of so-called nucleus pulposus compression is in reality myofascitis or some other spinal column condition However the condition may exist and every effort must be made to rule out the possibility of cord or nerve root pressure from a thickened ligamentum flava, or displaced intervertebral disc. This is especially true in those cases which do not present evidence of anomalies of the lumbosacral spine, and fail to respond to active conservative treatment Active coöperation between the neurologist the roentgenologist and the orthopedic surgeon is necessary to determine the existence of such a condition and to prevent useless exploratory operations The routine use of lipiodol myelography is never indicated but rather to be condemned since the symptoms are

often exaggerated following its use The authors at all times have many patients who will testify to this.

Myofascitis and Gynecological Conditions An endocervicitis may be the toxic or infective condition producing a myofascitis and in the general course of examination, a routine pelvic examination should always be included A severely lacerated or relaxed pelvic floor may be a source of backache but cannot be expected to produce the acute symptoms which are so often present Of 18 cases in which different types of pelvic operations were performed, and two cases *in which operation was refused* all were relieved when the pelvic treatment *was supplemented by that for myofascitis*

Myofascitis and Malignancies Myofascitis sometimes complicates malignancies particularly bony malignancies Malignancy should be considered in every case of atypical myofascitis, and especially one not responding promptly to the proper treatment Before treatment is continued in such cases the existence of such a condition must be eliminated

Myofascitis and Neurosis Neurotic patients or compensation cases *with simulated low back pain are matters of daily observation in every* clinic. Each of these cases must receive a thorough examination to rule out any possibility of pathology It is often advisable to make a complete examination of the patient roentgenologically, but to an advised expert the deception is usually obvious

Treatment In most instances of low back pain, the lesions or underlying factors are presumed to be toxicity or metabolic disturbances Hence when found treatment is primarily directed at their elimination, and secondarily at the local orthopedic manifestations The authors are convinced that *conservative* treatment is the procedure of choice in the great majority of cases of low back pain operative intervention being reserved for those few cases which fail to respond to proper treatment or present a definite indication for operation. By conservative treatment is *meant elimination at the source of toxicity or focal infection* rest in special positions in the acute cases supports when necessary colonic lavage in *those cases presenting evidence of toxic absorption* from the colon medication and physiotherapy Braceage is used to alleviate severe acute symptoms *and rarely in the subacute or chronic stage*

Elimination of Focal Infection and Toxicity Of the many possible foci of toxicity teeth head the list in point of frequency and in the majority of the authors cases, the oral cavity has been the offending source It has been observed further that in cases of long standing oral infection whether the primary source is the tonsils, the teeth, the antra or other sinuses, there is likely to be a residual toxicity in the colon When the primary oral focus has been eliminated it has become common practice to carry on a supplementary elimination treatment of the colon In 12 per cent of the Albee series the colon was found to be the only offending source

Careful x rays of all teeth must be taken in every case suspected of focal infection It is impossible to determine the existence of an abscess at the root of a tooth by inspection, tapping the tooth or by electrical stimulation The offending tooth may never, and usually does not give symptoms locally but due to constant absorption of its pus and toxins, a myofascitis may develop in the lower back muscles and fascia. An abscessed tooth which produces pain and swelling locally usually does not produce sufficient toxins for the production of a severe myofascitis

The nasopharynx and accessory sinuses may be a source of infection and when there is any evidence of disease in this area, a competent consultant should determine the extent of possible absorption of toxins. When disease is found every effort must be made to clear up the condition Infections of the genitourinary system must be eliminated and endocervicitis considered as a possible toxic source

Complete examination of the stool should be a routine procedure with all patients suffering from myofascitis After studying hundreds of cases in which stool examination has been made we are convinced that histamine in large quantities is an index of toxicity of the stool whether it is the principal offending toxic agent or not Gallbladder studies should also be made when there is suspicion of disease Infection in the gallbladder is quite common, and is often the focus To relieve this condition frequent biliary drainage and if necessary an autogenous vaccine are recommended

Colonic Lavage Following a report indicating toxicity the colon should be treated daily with medicated lavage There is no need for extensive apparatus A great deal of undesirable practice has grown up in the

use of more or less complicated apparatus to impress the patient but the lavage usually accomplishes very little toward lavage of the entire colon. It is claimed that the average colon has about 500 square inches of surface Some of the elaborate apparatus, particularly of the two-way type, unless it is correctly used brings the fluid into a particular spot of the colon, and discharges it through another tube at practically the same point, thus reaching only a few square inches of the colon The patient impressed by either seeing or hearing the flow of water for a considerable period of time through a tube and out of the colon, believes that his entire colon has been thoroughly washed.

The actual lavage is much more thorough when carried out by a short glass anal tip and ordinary fountain syringe volume of the fluid, posture and gravity being trusted to assure the fluid reaching the upper portions of the colon

The administration of this lavage must be handled by some one having experience. Although it is a simple procedure, it is not entirely harmless or free from accident There have been cases registered of rupture of the colon during a colonic irrigation, and even of severe hemorrhage after the administration of such a treatment

Introduction of Bacillus Acidophilus by Mouth or Colonic Implantations Much has been accomplished by sweeping out the abnormal mucus acid toxic products and bacteria from the colon but one should never rest with this lavage as it is very likely to have only temporary benefits, and the same harmful products may slowly reaccumulate Inasmuch as the bacterial flora have such a marked influence upon the proper function of the colon every effort should be made to influence the development of the proper flora The bacterial agent which the authors use to accomplish this is *Bacillus acidophilus* Its growth in large numbers may be stimulated in several ways

It has been revealed by careful study that when a patient is given lactose for a considerable period of time, the *Bacillus acidophilus* will slowly increase in the colon The substitution of lactose (two tablespoonsful or more per 24 hours) for table sugar should be carried out. This is not unpleasant to the patient as it can be used for sweetening coffee cereal etc. but inasmuch as some people eat but little sugar the point should be emphasized that the quantity prescribed must be taken as faithfully as

medicine For treatment purposes, this method alone is entirely too slow It is therefore wise to administer by mouth before each meal, two tea spoonsful of a culture containing not less than 200,000,000 active bacilli per cubic centimeter If the patient prefers, various milk preparations or acidophilus-charged beverages may be used The bacilli may also be implanted in a small quantity of water and lactose with a catheter, after the last lavage

Heliotherapy In all cases, heliotherapy is most beneficial However, to prevent overexposure and interference with physiotherapy, systematic exposure to the actinic rays of the sun must be carefully supervised

Diet A low residue diet which prevents carbohydrates from reaching the colon in undigested form is prescribed As Finker and von Wasser mann have proved that autointoxication is the result of bacterial activity on certain sugars, elimination of the offending sugar from the diet, and the substitution of lactose for ordinary table sugar may account for the beneficial relief

To forestall any possibility of residual protein reaching the colon in undigested carbohydrates or bringing with it partially digested carbohydrates and liberating them in the colon, proteins and meats are taken in moderate quantities only and the importance of thorough mastication is impressed upon the patient.

To help restore the alkaline balance citrus juices, particularly tree-ripened grapefruit juices or alkaline waters are given frequently One gram (15 grains) of calcined magnesia and calcium lactate are often given in water after eating, three times daily This regime tends to over come, without harmful cathartics, the constipation which is so frequently present in cases of myofascitis

Rest Rest in bed is reserved entirely for the very acute cases or for those suffering from acute exacerbation The position of most complete relaxation of the muscles and the fascia overlying the sacrum and lower lumbar spine is obtained by placing the patient in the supine position on a flat firm bed, with the lumbar spine flat, and with about a 30 degree flexion of both hips It is possible to keep the patient fairly comfortable in this position for a considerable period by placing pillows under the flexed knees When a change of position becomes necessary the same

degree of relaxation may be obtained in the prone position by placing a pillow under the abdomen.

During the period of rest in bed, which varies considerably in every case, physiotherapy in the form of heat and gentle massage of the lower back should be started This undoubtedly decreases the length of bed rest required, and greatly increases the patient s comfort by relaxing the muscle spasm increasing the circulation, hastening the absorption of inflammatory exudate from the fascia and muscles and preventing the marked atrophy of soft tissue

The period that the patient must be kept recumbent varies greatly and is usually longer in the chronic cases presenting an acute exacerbation of their symptoms Exercises and firmer massage may be started after the acute pain and muscle spasm begin to subside The patient is gradually allowed to increase his exercises and after about two weeks of recumbency, is usually able to resume limited activities However the treatment is prolonged, and physiotherapy must be continued for a considerable period before usual activities which may cause lameness in the beginning can be undertaken.

Local Mechanical Treatment Local mechanical treatment in the form of belts, corsets braces and plaster is applied when indicated, but the treatment outlined alleviates local symptoms to such an extent that the need for mechanical treatment is surprisingly diminished and is entirely secondary and always temporary

When external support is indicated for the comfort of the patient or for the prevention of the return of acute symptoms because of a sudden unguarded movement, the brace or other form of support must fit firmly to the pelvis and the lumbar spine should be held midway between flexion and extension, the desired position for function The support should be removed for daily physiotherapy and should be discarded as soon as the symptoms permit It is not desirable to continue the support longer than is entirely necessary because of the restriction of circulation of lymph and blood in the muscles and the limited motion of the spine permitted which increases progressive atrophy of the soft parts and because of the mental effect on the patient often a hindrance to continued improvement

Physical Therapy Deep massage is a most important part of the treat ment, accompanied by repeated stretching of the lumbosacral region by

the physiotherapist s forcible flexion of the hips with the knees extended, without anesthesia, which often helps to give relief, especially in the chronic cases In this manner the muscular and fascial adhesions are ruptured or overcome The pain following the rupture of these adhesions may be quite severe for a few hours, but thereby motion is increased muscular coördination is improved, and balance of the entire body becomes more accurate, thus preventing further strain

Prophylaxis Undoubtedly outdoor exercise aids in maintaining normal metabolism, and patients who are on the threshold of myofascitis avoid occurrence by following a favorable daily regime In particularly stubborn cases the patient should be urged if possible to live in a warm sunny climate Particular attention should be paid to all sources of focal infection and especially to the gastrointestinal tract

OPERATIONS DEVISED FOR MYOFASCITIS

Several operations have been devised in an effort to relieve the symptoms caused by myofascitis but they have not been found necessary in the authors experience When low back pain is due to myofascial disturbances the symptoms almost always improve without resort to operative measures that is if conservative treatment is properly supervised and the underlying factor determined and eliminated An operation may give temporary relief by releasing the tension on the fascia and muscles but permanent relief cannot be expected until the true source of the disturbance is eliminated. The operations in use are often followed by dense adhesions, and the authors have often encountered patients who after one or more of such operations have symptoms more severe than previous to their operation The routine procedure in some clinics of injecting novocain or procaine into the lower back for temporary relief or diagnosis is also not recommended as the continued use of this technic often exaggerates the symptoms by increasing the adhesions in the muscles and fascia and increases the difficulty of administering the proper physiotherapy Manipulation of the lower spine under anesthesia is also unwise

The operations which have been devised for this condition are

1 Section of the Iliotibial Band *Ober Technic* An oblique incision four to six inches long, is made from the lower edge of the anterior

superior spine downward and backward to a point just above the level of the greater trochanter and just posterior to it. The skin and subcutaneous fascia are separated by clean dissection above below and posteriorly until a strip about two inches wide has been dissected well back over the anterior surface of the gluteus maximus muscle. The fascia is now divided from the anterior superior spine well back over the muscle. The fascia gaps at the incision, and the flaps are dissected off the muscles

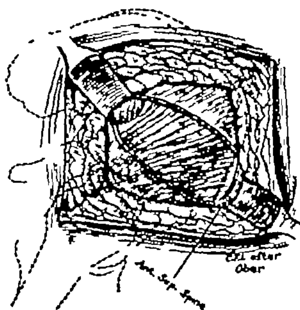


Fig. 195 Technic of Ober operation. Section of iliotibial band. *(From Operative Orthopaedics by Willis C Campbell—C. V. Mosby Co., St Louis 1939.)*

for about one inch on each side All intermuscular septa are divided If there is a positive Ely's sign the fascia surrounding the sartorius muscle is also divided All loose tags of fascial tissue must be removed. The length of postoperative time in bed depends on the severity of the back symptoms and the rapidity with which the sciatic pain clears up

2. Section of the Pyriformis Muscle This was suggested by Joseph A Freiberg, but a definite technic for division of the muscle was not recommended However the muscle is easily identified and resection of the lateral half is usually considered sufficient The approach to the muscle may be made by the Ober incision for posterior drainage of the hip joint.

3 Posterior Fasciotomy *Heyman Technic* A curved incision is made along the posterior superior spine to the posterior inferior spine and

carried downward to the bone The iliac origin of the gluteus maximus muscle is retracted subperiosteally to the superior gluteal line of the ilium and dissection is continued down to the upper margin of the great sciatic notch thence along the medial surface of the posterior superior spine to the sacrum and inferiorly to the posterior inferior spine Thus the posterior superior spine and the posterior third of the ilium are completely denuded of ligamentous and muscular attachments

Sacroiliac Joint Affections

Before the appreciation of myofascitis as the major cause of low back pain affections of the sacroiliac joint were almost routinely considered to be the chief etiological factor and still are in certain clinics Many designations were given to these affections and various types of treatment devised often without any appreciable results However since the senior author first described myofascitis and grouped the many individually designated conditions under one general head it has been learned that sacroiliac joint affections are usually of secondary importance as to frequency But in the careful differential diagnosis which is necessary to determine the true etiological factors in all cases of low back pain the presence of affections of these joints must be definitely determined The importance of these conditions as an underlying factor in the production of low back pain remains just as great, but the frequency of their occurrence, and the necessity for operation, have both greatly diminished in the light of present diagnostic knowledge, and the realization that the majority of low back pain cases respond to conservative treatment

The authors are convinced that surgical fusion of the sacroiliac joints for low back pain is not often indicated, and is only necessary when definite relaxation can be demonstrated or when tuberculosis or some other definite pathology is present. Due to the deep-seated position of the joints under the posterior wings of the ilium relaxation is almost impossible to diagnose definitely and before operation is considered, every means at one s command should be exhausted including careful x ray examination.

Etiology Affections and relaxations of the sacroiliac joint are produced by a number of causes

1 *Traumatism* Direct blows, such as sitting down hard, and severe strains following heavy lifting may result in relaxation of the ligaments of the joint. Traumatic relaxation may be sudden, or due to constant strain continued over a long period.

2 *Construction of the Pelvis* Because the female pelvis is less firmly constructed abnormal mobility is more easily obtained than in the male On the other hand because of the greater size and strength of these articulations in the male, when abnormal mobility does take place, disability is more marked than in the female

3 *Hyperemia* Congestion incident to pregnancy and menstruation leads to physiological relaxation of the joint.

4 *Attitudes of Posture* Prolonged standing in an awkward position as in extreme lordosis, or in a stooped position, are predisposing factors

5 *Obesity* The drag of a large pendulous abdomen produces lordosis and consequent strain of the pelvic joints

6. *Corsets* Straight front corsets lead to increased lordosis and produce pressure on the anterior portions of the iliac crests tending toward relaxation of the sacroiliac joints

7 *Atony of Muscles and Periarticular Ligaments* Prolonged support or postoperative recumbency may lead to relaxation Visceral ptosis also favors relaxation

8 *Tuberculosis* The tuberculous process usually extends from the sacrum as a sequel to disease of the lower lumbar vertebrae

9 *Gonorrhea* The sacroiliac joint may be invaded by the gonococcus in systemic infection following urethral involvement

10 *Osteomyelitis* Pyogenic infection of the contiguous sacrum or ilium may involve the joint

11 *Arthritis* The sacroiliac joint is susceptible to infectious proliferative (atrophic) and degenerative (hypertrophic) arthritis just as are the other joints of the body

12. *Developmental Peculiarities* Where the origin is obscure developmental peculiarities may be the etiological factor either by lessening pelvic stability or as a result of frictional irritation from a misshapen

bone rubbing against some part of the joint during normal or abnormal motion

13 *Postoperative Relaxation* After symphysiotomy, pubiotomy, etc Symptoms are never followed by such operation when the pelvic enlarge

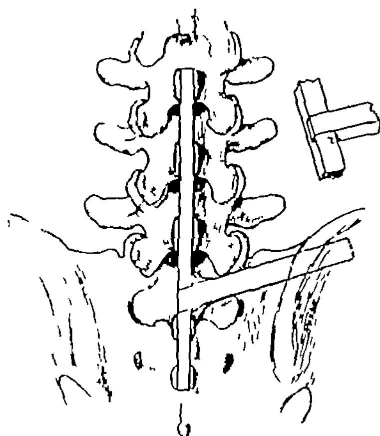


Fig. 196. Diagram from the roentgenogram of an actual case of tuberculosis of the last lumbar vertebrae and the right sacroiliac joint. The spine graft was inserted by the Albee regular technic for Pott s disease. The graft controlling the sacro-iliac joint was joined by a carpenter's half mortise to the spinal graft (see small upper right-hand drawing) The callus uniting the two grafts is indicated. The graft was joined to the posterior wing of the ilium by shaping it into a wedge end which was forced into a split in the ilium made by an osteotome (*From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York*)

ment is held and stabilized by the senior author s bone graft insertion

Pathology 1 *Relaxation of the Joint* Fluid from effusion may or may not be present as in other traumatic joint affections the condition being described as *moist* or *dry* Although abnormal mobility is very difficult to demonstrate occasionally movement may be felt by moving



Fig. 197 Roentgenogram of a case of tuberculosis of last lumbar vertebra and sacroiliac joint, of which Fig. 198-A is a drawing. *AB* is spinal graft; *CD* is graft for fixation of sacroiliac joint. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Co., New York.)*

the sacrum on the ilium, and vice versa X ray examination reveals an increase of the sacroiliac space

2 *Infections Sacroiliac Joint*

(*a*) Tuberculosis The disease may be bilateral but is usually unilateral The primary focus is in the articular surface of the ilium, or in the lateral mass of the sacrum, usually the latter, the disease often extending into this part from the lower lumbar vertebrae With the infection of the synovial membrane secondarily, the disease may spread to the articular surface of the ilium The detailed pathological process is the same as in osseous tuberculosis elsewhere in the body, except that ichor pockets (cold abscesses) are more common than is usually the case elsewhere Due to the thin anterior ligaments, the focalizing point is usually forward into the pelvis The intrapelvic abscess may extend outward into or beneath the sheath of the psoas, appearing in the groin or extending further, it may point more superficially, internal to the anterior superior iliac spine or it may pass downward through the sacroiliac notch and appear on the buttocks and in the ischiorectal fossa

(*b*) Degenerative (Hypertrophic) Arthritis This condition is usually unilateral and is characterized by a fusion of the joint In one of the senior author s dissections the anterior part of the joint was obliterated with a bony deposit which also extended into the posterior ligaments

(*c*) Pyogenic and Gonorrheal Arthritis The pathological character of the joint in these conditions is as it occurs elsewhere in the body Externally the periarticular tissues are swollen tender red and the surface temperature is elevated The joint cartilages are eroded in advanced cases and the joint may be distended with turbid fluid or pus

3 *Malignant Sacroiliac Disease* Primary malignancy of the joint is rare, but a malignant process may extend from the ilium or sacrum into the joint

4 *Congenital Anomalies* Congenital absence of the pubic bones may produce pathological relaxation of the sacroiliac joints while it is probably true that many disturbances of this joint of obscure origin depend upon developmental peculiarities In many cases of exstrophy of the bladder a considerable portion of the anterior segment of the pelvic ring is absent and where the gait is much affected or the symp-

toms severe enough, the operative restoration of the defective anterior segment of the pubic arch by a bone graft may be justified

Differential Diagnosis. 1 *Relaxation of the Joint* This is exceedingly difficult to diagnose, due to the deep-seated position of the joint behind the posterior wing of the ilium making palpation impossible In lesions of the pelvic joints there is almost invariably limitation of some of the motion, but in certain cases there is also an increase of the normal motion This increase will naturally be seen chiefly in the cases in which as the result of long-continued strain, the joints are much relaxed Every effort should be made to determine if relaxation of the joint exists and various tests have been evolved to determine this Forced hyperextension of the thighs, one at a time, thus moving the ilia on the sacrum, may be of value. With the patient standing if one hand is held over the sacrum while the pubic bones are held between the thumb and finger of the other hand, and the patient raises first one knee, and then the other the motion may be quite distinct Again if the crests of the ilia are grasped by the two hands the thumbs resting on the sacrum, and the patient raises the legs as above mobility is usually apparent So, although increased mobility may be elicited by any or all of these tests, it should be borne in mind that while there is an abnormal amount of motion under certain conditions, there is also in these very cases under other tests definite limitation of motion.

The pain in attitudes of standing or walking when there is relaxation of the joint was once thought to be pathognomonic but we know now that several conditions may produce the same symptom complex Myofascitis and pressure upon the cauda equina or nerve roots from a ruptured nucleus pulposus or hypertrophied ligamentum flava will also result in peculiarities in the use of the body which may be identical Careful roentgenological orthopedic, and neurological consultation is often necessary to distinguish the true cause.

2 *Infections Sacroiliac Joints*

(*a*) Tuberculosis of the sacroiliac joint or lumbar Pott s disease must be eliminated This is usually not difficult as the history physical signs and roentgenograms are usually definite

(*b*) Osteoarthritis may be eliminated by the presence of arthritis elsewhere in the body, or by the finding of definite evidence of the disease in roentgenograms of the joints

(*c*) Pyogenic and Gonorrheal The swelling of the joint may be visible and is often palpable The character of the swelling will depend upon the nature of the lesion, and is usually less in nontuberculous types The muscular atrophy is slight and this together with the more acute onset and the usual involvement of other joints should make differentiation possible Tuberculosis of this joint is usually metastatic.

(*d*) Hip Disease There is limitation of the motion of the hip in all directions and the muscular rigidity of the hip muscles is marked X ray examination is usually sufficient for diagnosis

Treatment The treatment of relaxation and affections of the sacroiliac joint depends upon the extent of the lesion and its pathological character Although *it is very difficult to diagnose definite relaxation of* the joint, it is possible by a process of elimination, and when there is reason to believe that relaxation is the cause of low back symptoms the joint should be fused by inlay bone graft but only when definite relaxation does exist. Tuberculosis of the joint should be fused by extra articular grafts and when it becomes necessary to fuse the joint for arthritis the fusion should also be extra articular However, fusion of the joint for arthritis is rarely indicated because hypertrophic arthritis of the sacroiliac joint is usually associated with generalized arthritis of the spine and other joints, so conservative measures are indicated

Conservative Treatment 1 Strapping A thick pad of felting measuring five inches by six inches is applied to the sacrum. Two-inch adhesive straps are made to half-encircle the pelvis tightly just below the anterior superior iliac spines These should extend from the extreme anterior part of the ilium on one side, around the buttocks to a similar point on the other side, and be carried up and down until the buttocks and lower lumbar spine are covered. The strapping and pad should be reapplied when it becomes loose until the symptoms are relieved and then a wide webbing belt should be worn for not less than six months

2 Wide Webbing Belt. Such a belt attached to the base of a long corset in women reinforced with light steel strips to prevent wrinkling, and with a firm pad over the sacrum may give relief



Fig. 198. Exposure for extra-articular arthrodesis of sacroiliac joint. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Co., New York)*

3 Night Supports It is more essential to support the bones during recumbency than in the waking hours for at night the pain is often exaggerated A firm pillow fitted under the hollow of the back to prevent flattening of the lordotic curve or transferred to the side when the

patient assumes the lateral position, supplemented by another pillow below the knees, has been found of value In the very obstinate cases with great pain, a plaster bed may be made so that the back sacrum, buttocks and thighs are supported

4 Double Spica Cast If the patient is subject to extreme pain and no relief has been obtained by either of the above methods, it may be necessary to apply a double spica cast until the severe symptoms have subsided

Operative Treatment When it has been definitely determined that a true relaxation of the joint exists the joint should be fused by the inlay bone graft method The author has devised the following three methods for fusion of the sacroiliac joint

1 INLAY BONE GRAFT INTO THE SACROILIAC JOINT ITSELF

(Indicated for non infectious relaxation of the joint)

The joint is reached through its posterior ligaments just to the inner side of the posterior wing of the ilium The under surface of the wing of the ilium as well as the posterior surface of the sacrum are denuded by means of the osteotome and the motor burr or end-mill The dimensions of the gutter thus formed are obtained accurately with compasses or inside calipers The graft, of dimensions to fit this gutter, is obtained from the tibia in the manner described on page 187 in the chapter on tuberculosis The graft, a little wider at one end than the other is then driven into place by means of a mallet and the bone peg set As it is wedged in by being driven in end ways it fits tightly and requires no retaining fixation sutures

2 BRIDGE BONE GRAFT FROM SACRUM TO WING OF ILIUM

(Especially indicated for tuberculosis or some other infection)

With the patient on the face in the prone position, and both spinal and tibial fields prepared, the posterior wing of the ilium and the upper portion of the sacrum, are approached by a curved incision so placed that the line of skin sutures will not lie directly over the graft

The first spinous process of the sacrum is split *en masse* with its enveloping ligaments and soft tissues the cleft being made not verti

cally but at right angles to the long axis of the spine The upper half of the split process is left attached to the sacrum and unbroken the lower half is fractured at its base and displaced downward. On account of its small size, the first sacral spinous process may be fragmented by repeated attempts to split it in equal parts, but this interferes in no way with the ultimate result if the fragments are left attached to the enveloping ligaments

The periosteum of the posterior surface of the sacrum where the graft is to be contacted is split in line with the cleft in the spinous process and peeled downward with the sharp periosteal elevator The underlying bone is then scarified over a considerable area for contact with the graft

The mesial surface of the posterior wing of the ilium projecting beyond (toward the midline) the sacroiliac joint is developed and a cleft is made by driving a ½ inch osteotome into it in a plane parallel with the prepared posterior sacral surface for the reception of the distal end of the graft. In making this cleft the handle of the osteotome is pressed down as tightly as possible against the posterior surface of the sacrum The distal end of the graft is bevelled in such a way that, on being forced into its bed in the ilium, its proximal (sacral) end is tightly coapted to the posterior surface of the sacrum The field of operation is then temporarily packed with hot saline compresses while the graft is being prepared

The leg from which the graft is to be removed is flexed backward and the bone graft ½ inch or more in width and of the desired contour is removed from the antero-internal surface of the tibia. Its distal (iliac) end is bevelled on its periosteal side (which is to be the posterior side) so that it may be driven tightly into the cleft in the ilium by means of the Albee bone peg set As much of the marrow substance as possible is left on the graft Numerous fragmented grafts obtained from bevelling the iliac end of the graft and from the edges of the tibial gutter are placed about the points of junction of the graft with the sacrum and ilium.

Ligaments and soft tissues are now drawn over the graft by medium sized kangaroo tendons and chromic sutures and the wound is closed with a continuous suture of No 0 plain catgut in the usual manner

Postoperative treatment consists of recumbency in bed for six weeks or longer, if considered necessary

3 INLAY BONE GRAFT FROM WING OF ILIUM MORTISED INTO A PREVIOUSLY INSERTED SPINAL INLAY BONE GRAFT

(For combined tuberculous disease of lumbar vertebrae and sacro-iliac joint)

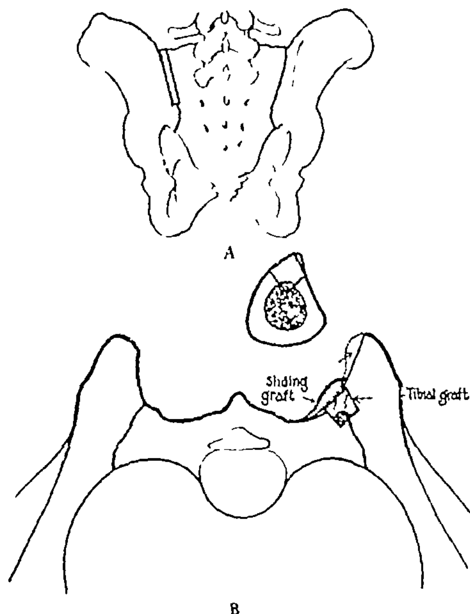


Fig. 199 *A* and *B* indicate tibial inlay graft inserted into the sacroiliac joint for surgical arthrodesis in a case of osteoarthritis of this joint, failing to be relieved by conservative treatment. *(From Albee Bone Graft Surgery in Disease Injury and Deformity D Appleton-Century Company New York)*

The posterior superior spine, and wing of the ilium, and first spinous process of the sacrum, are reached by a curved incision The spinous processes of the last one or two lumbar vertebrae are split with their attached ligaments, by a wide osteotome, to form a gutter for the ends of the graft A cleft is made in the posterior wing of the ilium by driving a thin ½ inch osteotome into it just anterior and mesial to its posterior spine, and in a lateral direction from within out. The lateral graft, which is later secured is formed with a wedge-end to be driven into this cleft

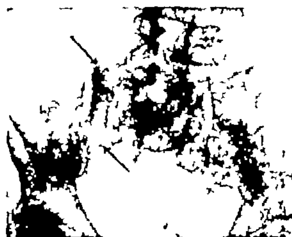


Fig. 200. X rays of sacroiliac joint after bone graft fusion illustrated in Fig. 199-A and B.

the other end being joined by a carpenter s half mortise to the spinal graft.

The surface of the sacrum is denuded to furnish additional contact with the graft. The wound is packed with a saline compress and with the patient still in the prone position the leg is flexed and a graft of sufficient length removed from the crest of the tibia by the motor saw to furnish material for the spinal graft and the lateral bridge to the ilium The width of the graft should be three times the thickness of the cortex The thickness should include the whole cortex, periosteum, endosteum and a small amount of the adhering marrow The spinal graft is placed in its prepared bed and the ligaments are drawn over it by interrupted sutures of medium kangaroo tendon

Before the kangaroo tendon sutures are drawn over the lower end of the spinal graft, a segment is removed from its uppermost surface and into it one end of the lateral graft is half mortised and the other wedge

shaped end is driven into the cleft in the ilium prepared for its reception

The skin wound is closed and the patient placed on the back on a fracture bed for a period of not less than six to eight weeks There should be no necessity for further mechanical supportive treatment

(If both sacroiliac joints are affected, a lateral graft is inlaid from sacrum to ilium on each side after the manner described above for unilateral relaxation)

CAMPBELL S EXTRA ARTICULAR METHOD OF FUSION OF SACROILIAC JOINT

An incision is made along the outer lip of the crest of the ilium from the posterior one third or one half to the posterior inferior spinous process, and the soft structures are divided to the bone. The periosteum is incised and elevated over the crest and upper portion of the dorsum of the ilium and the erector spinae muscles are retracted toward the midline. Beginning at the posterior spine, and continuing around the crest of the ilium, a graft ¾ inch wide, and 3 inches long is outlined by multiple cuts with a chisel, removed and placed in a towel The inner table of the overhanging portion of the ilium, and the adjacent posterior surface of the sacrum are denuded Thus, a gutter of cancellous bone is formed by the posterior surface of the sacrum, and the inner surface of the ilium posterior to and above the sacroiliac joint Into this gutter is inserted the graft from the crest. The surrounding space is filled with multiple small grafts or shavings from the dorsum of the ilium The mass of bone is then impacted with a blunt instrument, such as that designed by Joseph Freiberg for this purpose

After Treatment The patient is placed on a Bradford Frame for a period of two weeks. The stitches are then removed and a cast applied from the nipple line to the knees Eight weeks after operation, the patient is permitted to walk, supported by a long Taylor spine brace with sacroiliac attachments

SMITH PETERSEN INTERARTICULAR ARTHRODESIS OF THE SACROILIAC JOINT

The incision is made along the posterior two-thirds of the iliac crest curving around the posterior superior spine, and then continuing paral

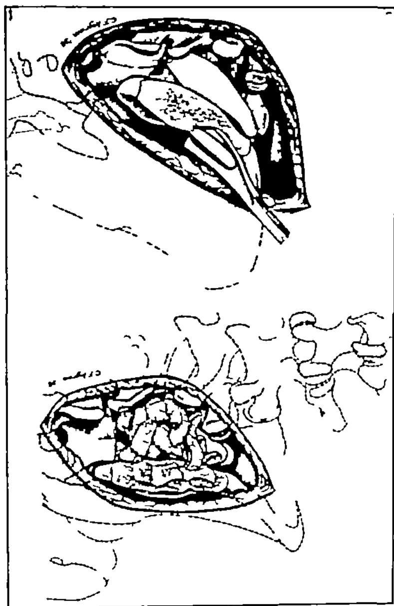


Fig. 201. Inner table of ilium and adjacent posterior surface of sacrum denuded graft from ilium countersunk into this area. Multiple small bone grafts fill intervening spaces. (*From Operative Orthopedics by W C Campbell—C V Mosby Co., St Louis 1939*)

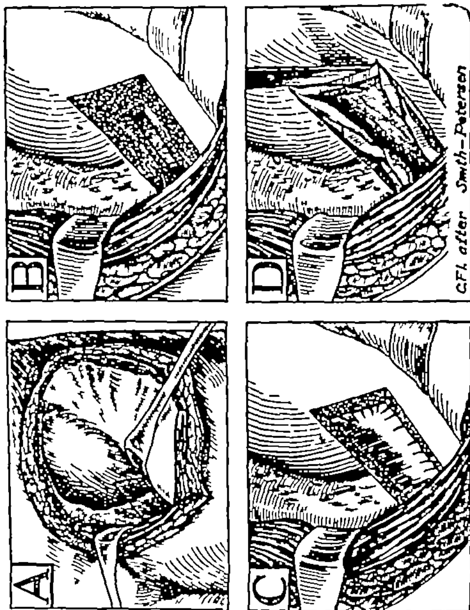


Fig. 202. Smith Petersen intra-articular arthrodesis of sacroiliac joint. *A.* Outline of section of bone removed from ilium sacroiliac joint and sacrum. *B* After removal of bone plug *C* Cartilage resected from joint surface and block of bone replaced and countersunk. *D* Edges of window osteotomized and fragments turned inward (*From Operative Orthopaedics by W C. Campbell C V Mosby Co St Louis 1939*)

lel with the fibers of the gluteal muscles a distance of two or three inches The soft tissues are reflected subperiosteally, exposing the lateral surface of the ilium A rectangular window is then removed from the ilium directly over the sacroiliac joint The sacral surface of the joint is divested of cartilage down to the cancellous bone. After resection of the cartilage from the joint surface of the block of bone, the block is replaced and countersunk so that its cancellous surface comes in contact with the cancellous bone of the sacrum The block is further secured, and osteogenesis promoted by osteotomy of the edges of the window and the turning of the fragments inward

CHANDLER'S METHOD OF TRISACRAL FUSION

A crescentic skin incision with its convexity downward is made transversely along the posterior margin of the iliac crest crossing the mid line one inch below the level of the posterior superior spine and terminating on the opposite crest of the ilium The spinous processes of the fourth and fifth lumbar vertebrae, and the first and second sacral vertebrae are exposed by a midline incision of the deep structures Arthrodesis is carried out by the Hibbs technic—except that in this case the spinous processes are only partially amputated The midline incision of the deep structures is temporarily closed The posterior superior spine of the ilium is exposed the posterior iliac crest and spine are split parallel to the flat surface to the level of the posterior margin of the sacroiliac joint, and the outer portion is reflected laterally The inner table of the ilium is excised and preserved in warm saline solution to be used for grafts.

The adjacent portion of the sacrum is roughened by means of a small gouge The posterior margin of the cartilage which presents in the depth of the wound is detached from the sacroiliac joint Chips of cancellous bone are removed from the ilium and packed across the sacroiliac joint posteriorly The reflected outer table of the ilium is then approximated to the roughened surface of the sacrum and sutured in place and the opposite sacroiliac joint is treated in the same manner The midline incision is next reopened and the resected portion of the inner table of the ilium split into two grafts which are placed adjacent to the denuded and partially amputated spinous processes Both incisions are then closed

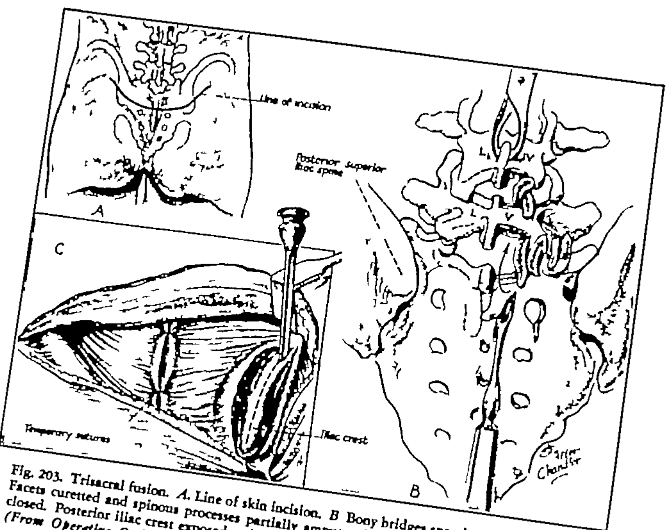


Fig. 203. Trisacral fusion. *A.* Line of skin incision. *B* Bony bridges span interlaminal spaces. Facets curetted and spinous processes partially amputated. *C* Midline incision temporarily closed. Posterior iliac crest exposed and split to level of posterior margin of sacroiliac joint. (*From Operative Orthopaedics by W C Campbell C V Mosby Co St Louis 1939*)

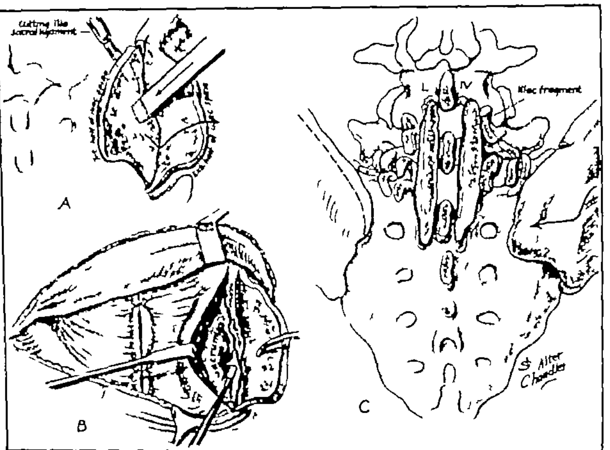


Fig. 204 Same as in Fig. 203-A, B, C. *A.* External portion of ilium reflected and inner portion excised. B. Periosteum of sacrum reflected medially cartilage of sacroiliac joint curetted; cancellous bone chips fill iliosacral angle. *C.* Reflected portion of ilium covers posterior surface of sacroiliac joint and is sutured to periosteum of sacrum. Excised fragment divided and placed on each side of spinous process to reinforce lumbosacral fusion. (*From Operative Orthopaedics by W C Campbell C V Mosby Co St Louis 1939*)

Anomalies of the Lumbar Spine and Sacrum in Relation to Low Back Pain

The lumbosacral junction is the portion of the human spine most vulnerable to mechanical strain and at the same time most often involved in anatomical defects and anomalies Anomalies may weaken the anchorage of the spinal column to the pelvis, or expose the last presacral nerve roots to stress impingement or chronic irritation from disease or posture.

The anomalies or defects having a bearing on low back pain are

1 Sacralization of the Fifth Lumbar Vertebra or Lumbarization of the First Sacral Segment The addition or substraction of a lumbar vertebra may weaken the spinal column but it is doubtful that the stability is decreased to any appreciable extent, as many cases presenting such a deformity do not complain of low backache unless there is impingement or articulation of the enlarged transverse processes with the sacrum or ilia

Low back symptoms are unlikely when there is a complete bilateral fusion of the transverse processes of the fifth lumbar vertebra to the sacrum The fifth lumbar vertebra then becomes an integral portion of the sacrum, but there may be some limitation of motion of the lumbar spine The transverse processes of the fifth lumbar vertebra may be so large as to impinge upon the upper border of the sacrum or ilium and present an irregular fusion or pseudoarthrosis and it is reasonable to believe that this asymmetrical anchorage of the last lumbar vertebra to the pelvis predisposes to strains and interferes with normal recovery from injury

The narrowing of the lumbosacral interspace, which is often the case in sacralization of the fifth lumbar vertebra diminishes the size of the neural foramina through which the last lumbar nerve passes and thus the liability of injury to these nerves is increased especially when there is incomplete or unilateral fusion. The motion allowed between the fifth lumbar vertebra and the sacrum when there is a pseudoarthrosis or unilateral fusion, is often sufficient to produce pressure on the nerve roots in the congenitally contracted foramina

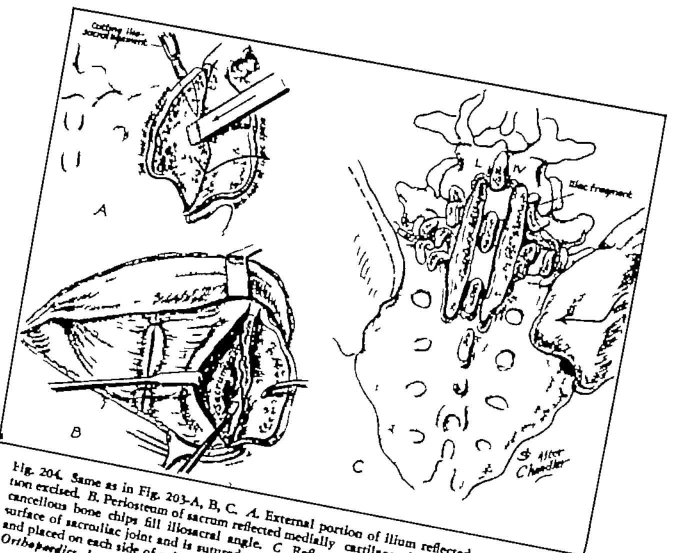


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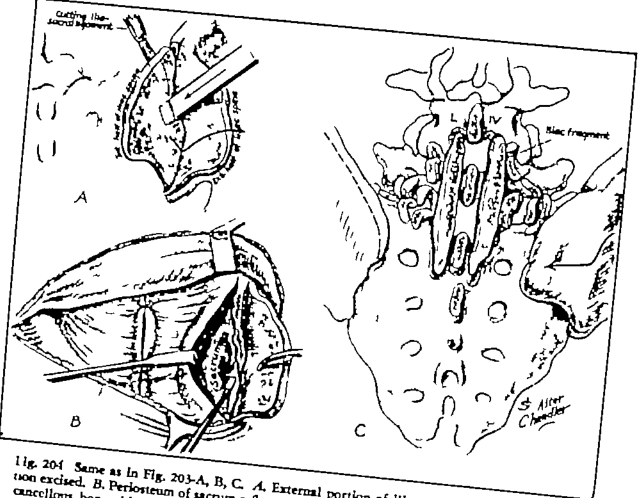


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Since the treatment required is to restore stability spinal fusion is indicated

Osteoarthritis of the Lumbar Spine and Sacroiliac Joints

Osteoarthritis is a source of low backache and is often accompanied by myofascitis The authors have encountered many cases of low back pain of short duration in which there was no evidence of joint involvement or other pathology except for myofascitis on the original examination, but on later examination and especially in those cases which had received inadequate treatment for myofascitis moderate to-advanced joint changes and lipping of the vertebrae were revealed For this reason it is believed that myofascitis is a pre arthritic condition and symptoms of the former are considered as danger signals that the latter is impending

The treatment of arthritis of the spine has been covered in the chapter on that subject, but arthritis of the lower lumbar spine and sacroiliac joints presents a slightly different picture when associated with prolonged low back symptoms When a case is seen early every effort must be made to eliminate every source of toxicity and with conservative treatment the patient may be kept quite comfortable. However in the advanced cases when the low back pain is definitely attributed to the arthritic changes conservative treatment may not suffice, except to relieve the accompanying myofascitis symptoms which are invariably present Conservative measures must always be given a fair trial before any operative procedure is recommended and fusion of the lumbar spine or sacroiliac joint should never be attempted except in selected cases in which the arthritis is definitely localized In these selected cases fusion of the lumbar spine is best accomplished by the Albee inlay bone graft technic while fusion of the sacroiliac joint by either the inlay or extra articular methods will prove satisfactory

Influence of Gynecological Conditions on Low Back Pain

It has long been realized that there is a physiological relaxation of the sacroiliac joints during menstruation and pregnancy which give rise, in most instances to temporary moderately advanced low back symptoms but it is doubtful whether malpositions of the uterus infec

Treatment See chapter on congenital deformities and anomalies of the vertebral column for the general and operative treatment of this condition.

2 Inequality in the *Anterior Posterior Diameter of the Opposing* Articular Surfaces of the Sacrum and Fifth Lumbar Vertebra Willis has determined that the superior articular surface of the sacrum is decidedly variable in form, and a decrease in the anterior posterior diameter as compared with the inferior lumbar surface opposing it, is quite frequent The lumbosacral joint may become unstable due to this inequality, or a source of low back symptoms and if definitely determined, fusion is indicated

3 Spina Bifida—Occulta When occurring in conjunction with a prespondylolisthesis or true spondylolisthesis or without forward slipping of the fifth lumbar vertebra on the sacrum, this may be a source of low backache by producing instability of the lumbosacral junction or the pain may be due to defective development of the spinal cord or nerve roots

The pain in this condition probably is due to the instability rather than to defective nerve development as the lumbar spinous processes serve as large attachments for muscles and ligaments that stabilize the back, and when the lower lumbar and upper sacral processes are absent, greater strain is placed on the maldeveloped ligaments Treatment of this condition when it is a source of low back symptoms is spinal fusion of the lumbar vertebrae to the sacrum by inlay bone graft

4 Lesions of the Spinous Processes The normal distance between adjacent spinous processes may become lessened due to congenital development or disease When two processes are in contact, a painful area may develop because of a pseudoarthrosis Also there may be a congenital elongation of a spinous process which remains tender

Treatment in both instances consists of excision

5 Asymmetry of the Lumbosacral Articular Facets It has been determined by Badgley and Willis that a great variation often exists in the lumbosacral articular facets When the articular facets have assumed a more or less sagittal plane, either from injury disease or development it is logical to believe that additional strain may be placed on the lower back ligaments and in some cases this may be a source of backache

graft into the spinous processes, including two vertebrae above and two below the injury, is the treatment of choice

Narrowed Lumbosacral Junction

This condition is frequently considered an etiological factor in the production of low back pain, the theory being that the spinal nerves passing through the corresponding foramina are impinged upon When it is definitely known to exist fusion of the lumbosacral intervertebral space is definitely indicated

Neurotic or Railway Spine

A full discussion of this functional disturbance of the nervous system, so frequently a cause of low back pain, appears in Chapter XIII on pages 423-425

Kümmell's Disease

This entity also while a frequent etiological agent in the production of low back pain is discussed in its fuller significance in Chapter XIII pages 422, 423

Defective Balance

Lateral and anteroposterior defects in balance may produce a static backache When one leg is longer than the other the pelvis is tilted obliquely and the spine curved to one side on standing—the muscles on the converse side therefore undergoing strain The discomfort is greatest when standing or walking and may be marked over the sacroiliac joint region of one side Flatfoot and other allied deformities of the feet may also produce back strain by producing abnormality of the base of support but in such cases treatment should also include a search for toxicity as well as correction of the deformity by operative procedures

Treatment of this condition consists of the elevation of one heel to correct the unilateral defects of balance the proper treatment of deformed feet and appropriate physiotherapy measures

Protrusion of the Intervertebral Disc

The extensive and rapid growth of the literature during the past seven years regarding protrusion of the intervertebral disc as a major

tions of the tubes or small ovarian cysts bear any relationship to low back pain. In certain instances marked relaxation of the pelvic floor with a moderate degree of prolapse of the uterus large uterine fibroids and large ovarian cysts will be a source of low back symptoms, either from mechanical stress upon the pelvic organs or from metabolic changes due to the interference with digestion One cannot go so far as to state that gynecological conditions have no bearing on low back symptoms, as this group of organs must also be studied in a search for focal or metabolic disturbances and it is definitely known that an endocervicitis is often a source of toxicity

Tuberculosis of the Lumbar Spine and Sacroiliac Joints

This condition must be definitely eliminated in the differential diagnosis of low back pain. The history of insidious onset, plus the positive x ray findings and slight to-advanced kyphosis is usually sufficient for diagnosis The treatment of this condition is fully described in the chapter on tuberculosis

Ununited Fractures of the Lower Spine

Ununited fractures of the lower vertebrae may be a source of low back discomfort Fractures of the transverse processes rarely unite due to their low osteogenesis but the pain from such injuries is seldom prolonged or severe Union of the fractures of the spinous processes may be delayed but the symptoms are most often confined to local tenderness Old and acute fractures of the pedicles and articular processes are very difficult to diagnose, and when there is a history of injury followed by prolonged disability a nonunion of these processes must be considered and oblique roentgenograms taken in an effort to determine their existence However extreme care must be exerted to prevent diagnosis of an anomaly as an old fracture

Old compression fractures of the bodies of the lumbar vertebrae especially those inadequately treated, may be a source of latent low back symptoms Often, in the search for the etiology of low back pain roentgenograms show an old compression fracture which was not diagnosed at the time of a slight previous accident Again fusion by inlay bone

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source of low back pain has been tremendous It is often suggested that the differential diagnosis is easy and the clinical picture typical even without lipiodol or air myelography and that laminectomy with the removal of the offending portion of the disc is the only treatment to be



Fig. 205. Complete transverse defect in the shadow of lipiodol in the neural canal due to protrusion of the intervertebral disc. *(Presented by courtesy of Louis G Howard.—From Roentgen Diagnosis of the Extremities and Spine by A B Ferguson Paul B. Hoeber Inc New York 1941)*

considered However the authors extensive experiences in diagnosis and treatment of low back conditions do not coincide with these opinions The orthopedic surgeon is called upon to treat thousands of cases of low back pain yearly and the great majority undoubtedly improve or are cured by conservative means without any operative procedures Those

cases which fail to improve under conservative care have definitely been benefited by spinal fusion,* in a large percentage of cases and the authors are satisfied that symptoms due to herniation of the nucleus pulposus are extremely rare, probably occurring in about two per cent of the cases presenting low back symptoms

When there is a definite suspicion of herniation of the disc, laminectomy alone is not always justified, as fusion of the lumbar spine by bone graft has relieved many cases suffering with symptoms identical with those described for herniation or protrusions and it is contended that the routine need for laminectomy has not been proven

Hypertrophy of the ligamentum flava with adhesions between the protrusion and the nerve root often occurs but it is doubtful that hypertrophy of the ligamentum flava alone is responsible for low back symptoms except in very rare instances

If protrusions of the discs are as frequent today as the number of operations performed for this condition indicate, what has been happening to these patients in the past? They have been relieved for the most part, by conservative treatment, and when operation was considered advisable, their spines have been fused with uniformly satisfactory results Those patients not so relieved, and those presenting definite cord or nerve root involvement, have been referred to the neurosurgeons for exploratory laminectomies and often the removal of a small dural tumor proved effective Such tumors were classified as chondromas etc. and were thought to be derived from the intervertebral disc It is possible that the frequency of protrusions today may be the result, in a large measure of the correct diagnosis of these so-called tumors as protrusions of the intervertebral disc.

Anatomy of the Intervertebral Disc Each intervertebral disc is of lenticular form and of composite structure and together they comprise approximately one fourth of the total length of the presacral portion of the spinal column Being placed between all adjacent vertebral bodies from the axis to the sacrum, they not only form the chief bond of connection between these bones but act as shock absorbers and with the

* Farrell, B P and MacCracken, W B "Spine Fusion for Protruding Intervertebral Discs, Journal of Bone and Joint Surgery 23 457 (April) 1941

source of low back pain has been tremendous It is often suggested that the differential diagnosis is easy and the clinical picture typical, even without lipiodol or air myelography, and that laminectomy with the removal of the offending portion of the disc is the only treatment to be



Fig. 205 Complete transverse defect in the shadow of lipiodol in the neural canal due to protrusion of the intervertebral disc. *(Presented by courtesy of Louis G Howard.—From Roentgen Diagnosis of the Extremities and Spine by A. B. Ferguson Paul B. Hoeber Inc., New York 1941)*

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spinal fluid within the spinal dura mater and the arachnoid serve as protection for the spinal cord and cauda equina.

The discs vary in size shape, and thickness in different portions of the spinal column, and are thinnest in the lumbar portion. The inequalities in the thickness of their anterior and posterior aspects are responsible in a large measure for the characteristic curves of the cervical, dorsal and lumbar regions—they are thicker anteriorly than posteriorly in the cervical and lumbar regions and uniformly thick in the dorsal region. Their size is greatest in the lumbar region since they correspond accurately with the surfaces of the vertebral bodies between which they are placed

The intervertebral discs are adherent to a thin layer of hyaline cartilage which covers the superior and inferior surfaces of the vertebrae and by their circumferences are closely connected in front to the anterior longitudinal ligament and behind to the posterior longitudinal ligament In the thoracic region, the discs are closely connected laterally by the interarticular ligament to the heads of those ribs which articulate with the two corresponding vertebrae The vertebral bodies and intervertebral cartilages are further supported by the ligamentum flava, the interspinous supraspinous and lumbosacral ligaments Under normal stress and strain the disc may bulge slightly beyond its normal confines to resume its normal contour when the stress is removed

To Schmörl we owe our present day conception of the intervertebral disc as a complex functional unit consisting essentially of three parts, the annulus fibrosus the nucleus pulposus and the cartilage plates The outer portion of the disc is composed of many layers of fibrous connective tissue the annulus fibrosus arranged concentrically passing in oblique and spiral directions from one vertebral body to the next The annulus is firmly attached into the adjacent bone by means of the so-called fibers of Sharpey and blends anteriorly with the anterior longitudinal ligament by means of well defined expansions The posterior longitudinal ligament supports the disc in the midline posteriorly but is ill-defined and often displays deficiencies where it is related to the disc. Microscopically the annulus is composed of fibrous and elastic lamellae and irregularly placed cartilage cells

The nucleus pulposus occupies approximately the center of the disc, and the transition between the annulus and the nucleus is indefinite

This central portion is composed of soft, very resilient semi fluid substance containing highly elastic fibrocartilage and some bands of connective tissue This semi fluid substance which possesses considerable elasticity in young individuals and is especially well developed in the lumbar region, contains a few remains of the notochord in the form of the physaliferous cells of Virchow The existence of a rudimentary joint space according to Luschka and Schmörl is still a matter of doubt

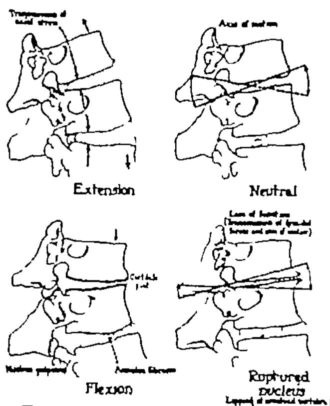


Fig. 206. A diagrammatic sketch illustrating the function of the intervertebral disc.

The opposing surfaces of the vertebral bodies are covered by the cartilage plates which should be considered as an integral part of the disc These cartilage plates are well defined in the central portion, but blend with the annulus fibrosus at the periphery It is upon the integrity of these cartilage plates that the confinement of the nucleus pulposus within the disc depends

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FUNCTION OF NUCLEUS PULPOSUS

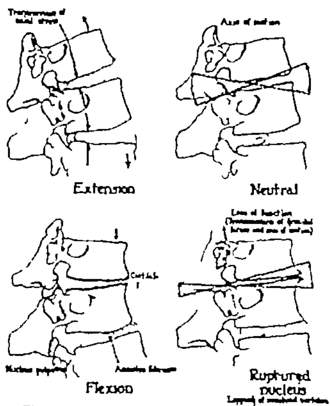


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stances the result of trauma. In some cases the patient may recall one outstanding injury but in many instances repeated trauma to the back, with aggravation or recurrence of preëxisting pain and disability is the etiological factor It is probable that repeated trauma may be necessary in many instances to produce sufficient protrusion to cause clinical symptoms The original injury may have weakened the longitudinal spinal ligaments and annulus without producing a true protrusion, the actual protrusion of the disc substance occurring at the time of a subsequent injury which may be slight as compared to the original Schmörl suggested that in some cases degenerative changes in the annulus fibrosus which may be due to trauma or possibly constitutional disturbances may predispose to the protrusion of the nucleus pulposus as a result of further trauma. Protrusions without the history of trauma, are definitely in the minority

The lesion occurs most frequently in the lumbar region, notably in the third, fourth, and fifth discs less frequently in the lower cervical region and rarely in the thoracic region. An apparently normal disc may be ruptured in a few instances, but it is the consensus that rupture usually occurs from the effects of trauma acting upon a disc already weakened by degeneration. This is indicated by the fact that the majority of cases occur in patients in the fourth or fifth decades, when degenerative phenomena are more frequent and in these cases extensive radiological examination of the entire spine often reveals degenerative evidence elsewhere

Pease, Melward and Grout have reported instances of damage to the intervertebral disc during routine lumbar puncture, the lesions having been produced by the needle passing through the spinal canal into the intervertebral disc If this should occur it is the result of extreme carelessness, and the possibility of its occurrence is negligible

The part congenital anomalies may play or the relationship they may have to the production of protrusions, has not been definitely determined. It is not unusual to see a protruded disc in the lumbar region of a patient with sacralization of the last lumbar vertebra a spina bifida occulta, or a lumbarized first sacral segment and Meyerding has found quite a large percentage of patients with spondylolisthesis and associated sciatica suffering from protruded discs.

Pathology Before protruded intervertebral discs were recognized as a clinical entity, many extradural cartilaginous or pseudocartilaginous tumors were removed or diagnosed They were termed chondromas, fibromas chondrochordomas fibrochondromas and osteofibrochondromas It was apparently recognized that these tumors, consisting predominantly of newly formed connective tissue, must arise from the intervertebral disc but they were not considered, in the majority of instances, to be protrusions of the disc, although approximately half of the cases presented a definite history of trauma followed by symptoms of compression of a nerve root These errors in diagnosis probably account for the rapid increase in the incidence of protruded intervertebral discs during recent years since by an accurate diagnosis of the material removed, the cause of the compression has been determined

The discs are seldom involved either primarily or secondarily in disease processes, whether infectious or malignant, since the discs like the epiphyseal plates of the long bones are extremely resistant to invasion The discs may undergo necrosis and be completely destroyed by an acute staphylococcic osteomyelitis, and are nearly always involved in tuberculosis spondylitis but they are extremely resistant to invasion by tumors

Most authorities agree that posterior protrusions of the intervertebral discs which are removed at operation are composed of all parts found in the normal intervertebral disc, that is the annulus fibrosus—the outer portion, a portion of the nucleus pulposus and sometimes a remnant of the embryonic notochord Degenerative changes are often seen especially in cases of protrusion occurring in the older age group There is a tendency toward replacement of the normal fibrocartilaginous structures of the protrusion by fibrous tissue and oedema of the protruded portion including both the annulus and the nucleus is a frequent finding

Nerve root symptoms may be produced by prolapse or herniation of the disc posteriorly either behind or on either side of the posterior longitudinal ligament, or more rarely anteriorly behind the anterior longitudinal ligament

Symptoms and Signs The clinical syndrome of rupture of a lumbar intervertebral disc with pressure on one or more spinal root nerves or the cauda equina is quite similar to many conditions producing low back symptoms and is often indistinguishable from myofascitis There are

no unique physical neurological, or orthopedic signs which are found only in cases of posterior protrusion of the disc, and diagnosis is therefore usually very difficult. In fact, a clinical differential diagnosis in *many instances is impossible.* The patient is usually a healthy individual between the ages of 20 and 50 with a chief complaint of radiating unilateral pain down the posterior aspect of the thigh and the posterolateral part of the calf, which came on with a sudden snap in the lower back. The location of the *pain, naturally, depends upon the location* or level of the protrusion

Protrusions in the cervical and dorsal regions are rare, but when present give symptoms which are very difficult to distinguish from extradural tumors of these regions However, the pain and symptoms show a greater tendency to intermittency than do neoplasms as tumors are more prône to show definite progression and severity of the signs and symptoms Protrusions in the lumbar region present symptoms which are often present in many other conditions producing low back symptoms namely recurring low back and sciatic pain which is chronic and intractable

The low back pain may be localized over the lumbosacral junction or over one or both sacroiliac joints with definite tenderness, but in the majority of instances the sciatic pain is unilateral The pain is usually accentuated by coughing or sneezing, straining at stool bending forward to tie the shoes lying face down in bed, and by any action which produces a temporary increase in intraspinal pressure. Night pain is usually *severe and often requires that the patient get out of bed and sit in a chair* or walk around several times each night There may be vague types of sensory disturbances, paraesthesia in the distribution of the involved nerve are common and some interference with sphincter control may occur A definite or slight atrophy of one or more groups of leg muscles is not infrequently seen and diminution or absence of the Achilles tendon reflex on the involved side is common.

Severe spasm of the lumbar spinal muscles is usually present, limiting all movements of the lumbar spine and the patient stands with his trunk thrust forward and to one side with most of his weight on the unaffected leg in the position which is often termed sciatic scoliosis A limping gait is usually noticed and the normal lumbar lordosis is often

obliterated, giving a flat back appearance, with prominence of the third, fourth, and fifth spinous processes

The straight leg raising test can be carried forward through an arc of about 70 degrees on the normal side, but there is definite limitation to 20 and 30 degrees on the affected side Any attempt to force the leg upward on the affected side produces severe pain in the lower back The patient gets on to the examining table with extreme care, and any change in position is quite an ordeal Any effort to restore the normal lumbar lordosis is very painful, and manipulation under anesthesia is not recommended

The knee jerks are usually normal but may be diminished A positive Kernig s test is usually present There may be segmental sensory loss with muscular weakness, but when extensive neurological signs are present an intraspinal neoplasm must be considered

Differential Diagnosis As has been said, the differential diagnosis of protrusion of the nucleus pulposus or hypertrophied ligamentum flava giving rise to low back symptoms, is extremely difficult and usually impossible as the symptoms and signs described as occurring in this condition are often identical with those of many other conditions The symptoms and signs of myofascitis are often the same as those described by most authors for protrusions with the lone exception of slight sensory disturbances and these are not a constant finding in those cases diagnosed as protrusions It is not denied that such a condition may exist but many are convinced that its existence is extremely rare, since the great majority of patients suffering from low back symptoms recover or definitely improve under carefully supervised conservative treatment without any form of operative procedure

It has been suggested that the gait is typical in protrusions and that the diagnosis is easily suspected by having the patient simply walk across the room but decrease of the lumbar lordosis inability to raise the straight leg positive Kernig s sign difficulty in getting upon an examining table scoliosis of the lumbar spine away from the affected side exaggeration of the pain on coughing and sneezing atrophy of the leg and thigh muscles from disuse a definite limp tenderness over the calf thigh, sacroiliac joints and buttocks inability to sit or lie down for considerable periods and tendency toward intermittency are all constant

findings in severe, untreated cases of myofascitis The authors have seen hundreds of such cases completely relieved of all these symptoms by carefully checking and removing some focal infection, such as an infected tooth or tonsils or by restoration of the normal intestinal flora, etc. in conjunction with daily supervised physical therapy

In the final analysis, the definite suspicion of a protruded intervertebral disc as a causative agent in the production of low back pain, must be reserved for the small percentage of those cases which have consistently failed to respond to conservative treatment, and which present positive evidence of the existence of such protrusion by special studies The differentiation must depend upon correlation of careful neurological, pathological and orthopedic examinations combined with reliable x ray interpretation of air myelography It is ridiculous to state that the diagnosis is typical and easy from the symptoms and signs alone, even without myelography as the diagnosis is often doubtful even after the injection of lipiodol, and many times the protruded disc is not found at operation following what is considered to be a definite positive lipiodol examination

Examination of the Spinal Canal by Contrast Medium The promiscuous use of lipiodol for patients suffering from low back pain is to be condemned. It is impossible to be certain there is a protrusion of an intervertebral disc, or to localize the protrusion definitely without the use of some contrast medium, but the injection of the medium should be limited to those cases which will probably come to operation, so that a portion or all may be removed at the time of operation If this procedure is followed, there will be fewer patients with lipiodol in their lumbar sac and cranium with associated painful symptoms

Most authorities agree that some form of radiopaque substance is essential for accurate diagnosis of a protruded disc, and the medium most universally used is lipiodol (40 per cent iodine in poppy seed oil) Even if diagnosis seems definite from positive findings as indicated by other tests the contrast medium is necessary to determine which disc is protruded, and rule out the possibility of existence of multiple lesions. This opaque oil has been of great value and has given excellent diagnostic results, but it must be remembered that lipiodol has marked disadvantages which must be borne in mind and which prevent its rou

tine use. It is slowly absorbed and may become encapsulated and act as a foreign body It is definitely a chronic irritant, and does cause pain in many cases A feeling of heaviness is often complained of in the lower spine after injection and as the patient changes position the oil is felt to move, giving an uneasy sensation which is very annoying to the nervous patient If the patient is tipped head down, and the oil is allowed to enter the cranium, either intentionally or accidentally a severe intermittent headache often results and the oil may become fixed there It is impossible to remove all the oil from the spinal canal, either by needle or by opening the dura at operation, and the oil should never be used when there is evidence of an inflammatory lesion.

When operative interference seems practically certain and lipiodol myelography is decided upon, a sufficient amount must be injected to fill the lower dural sac, and the amount sufficient for adults has usually been considered to be about five cubic centimeters but as small an amount as possible should be used, and some authorities now believe two cubic centimeters to be sufficient in many cases

The oil is carefully and slowly injected into the lumbar canal (only in the selected cases) while the course of the radiopaque substance is watched under the fluoroscope During the course of the fluoroscope examination any abnormalities of the column of oil is noted and the findings verified by x ray films without changing the patient s position An ordinary lumbar puncture needle is sufficient for the puncture, and the spaces between the fourth and fifth lumbar and fifth lumbar and first sacral vertebrae should be avoided, because extreme pain is felt when the needle passes through a protrusion, and these spaces are the levels at which the protrusion is most likely to occur

The use of air myelography has not proven as satisfactory as lipiodol as the margin of diagnostic error has been much greater and the severe headaches which often accompany the injection of air make its use prohibitive in many cases Air has the distinct advantage of being rapidly absorbed, but unfortunately the contrast between air and shadows cast by the bone is not sufficient to outline the smaller defects accurately When a radiopaque substance which is rapidly absorbable, and *not irritating* is developed the diagnosis of protrusions will be greatly simplified

The authors have had some experience with a new contrast medium which has been developed by Dr J Arthur MacLean of New York, N Y in which a special compound of di iodo-tyrosine has been used as a contrast medium with excellent roentgenographic results The great advantage of this material is that it is excreted completely by the body within about 48 hours This work is as yet unpublished but will in the authors opinion, prove its superiority over myelography by air

The routine examination of the spine without contrast medium is very disappointing, and not of aid in the diagnosis of a protruded disc, as the fibrocartilage is non-opaque. Occasionally a narrowed intervertebral disc may be suggestive of the location of a lesion, but one is never justified in making a diagnosis on its presence alone

Spinal Fluid Examination A diagnostic lumbar puncture is necessary in every case of suspected protrusion of the intervertebral disc. The needle should be introduced as low as possible in the lumbar region preferably at the lumbosacral junction, to avoid increased damage to an already protruding disc, and to be certain that the needle is below the protrusion The Queckenstedt test should be performed on all cases, although it is rarely positive in cases of protrusions in the lumbar region, and only occasionally in the cervical and dorsal regions Sufficient fluid should be removed for Wassermann and colloidal examination, and especially for total protein examination In the early cases studied, it was thought that an elevation of the total protein content of the spinal fluid was a very important feature in diagnosis of a ruptured nucleus as in diagnosis of intraspinal neoplasms but recently most authorities agree that the finding is so inconsistent as to be of little value

Treatment The great majority of patients suffering with low back pain recover with conservative treatment alone, but there is a small group which fail to respond to the usual conservative procedures and must be subjected to some type of operative procedure Fusion by bone graft is indicated for those with a spondylolisthesis or prespondylolisthesis which is producing symptoms Fusion is also indicated in certain cases of spina bifida occulta, localized arthritis, delayed union of fractures of the articular processes and vertebral bodies partial sacralization of the fifth lumbar vertebra and lumbarization of the first sacral segment, and in certain

other instances, but not before conservative treatment has been given a satisfactory trial, in most cases

Protrusion of the intervertebral disc is responsible for low back symptoms in a very small percentage of cases, and when this diagnosis is considered justified, three types of treatment must be considered

1 *Conservative Treatment* It is agreed that practically every case of suspected protrusion of the intervertebral disc should have the advantage of prolonged conservative treatment unless there is a definite paraplegia, which is extremely rare Before the sudden rise to popularity of protrusions of the intervertebral disc as a source of low back pain many of these cases were relieved by either conservative or operative orthopedic means and even today a great number presenting identical symptoms of pressure from a protruded disc, are relieved without laminectomy Roberts experience in relieving stubborn cases of low back pain by merely stripping the muscles from the local bony parts should be remembered Therefore the relief of a case diagnosed empirically does not prove the case a protruded disc, but does give rise to the question as to whether or not it was a case of myofascitis erroneously diagnosed

The conservative procedures which should be undertaken are

(*a*) Elimination of focal infection or metabolic disturbance (see p)

(*b*) Rest in bed—when the symptoms demand

(*c*) Immobilization in plaster—with the lumbar spine in slight flexion if the symptoms remain acute

(*d*) Modified Taylor spine brace—if further immobilization is necessary

(*e*) Daily physical therapy consisting of deep massage and mild stretching of the extremities without anesthetic

The authors have never recommended manipulation of the spine under general anesthesia for low back pain regardless of underlying factor as the procedure is extremely dangerous and may produce a paraplegia

2 *Bone Graft Fusion of the Lumbar Spine* Fusion of the lumbar spine to the sacrum by the Albee method as described under the treatment for spondylolisthesis has proven very satisfactory in the treatment of cases which fail to respond to conservative measures and which originally presented the same group of symptoms as now are described for hernia

tion of the nucleus pulposus The authors are of the opinion that the routine indication for laminectomy for those patients presenting clinical evidence of protrusion of the intervertebral disc has not been established and that the spinal fusion can be expected to continue to give routine satisfactory results in a large percentage of cases as is indicated by the

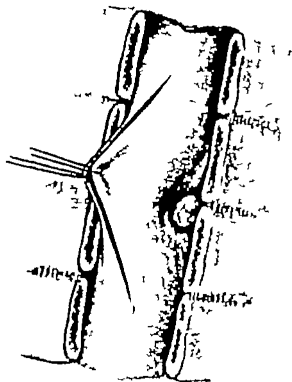


Fig. 207 A herniation of the nucelus pulposus a little lateral to the midline exposed at operation. The dura was first incised and several slips of the dentate ligament divided before the growth was approached extradurally (*From Elsberg Surg cal Diseases of the Spinal Cord Paul B Hoeber New York.*)

results obtained by Farrell and MacCracken * In a series of cases diagnosed as herniation of the intervertebral disc they alternated as to operative procedure, in one instance doing a fusion alone, and in the next instance doing fusion with supplemental laminectomy The ultimate findings were that the cases where fusion alone was done gave practically the same percentages of good results as those where the fusion was supplemented by laminectomy

* Farrell, B P and MacCracken, W B "Spine Fusion for Protruding Intervertebral Discs Journal of Bone and Joint Surgery 3 457 (April) 1941

3 *Laminectomy* It is only after repeated attacks of low back symptoms have occurred and after palliative measures have failed to give relief that one is justified in advising laminectomy

Procedure A general anesthetic is usually preferable—following a preliminary hypodermic injection of morphine sulfate 10 or 16 mg (gr

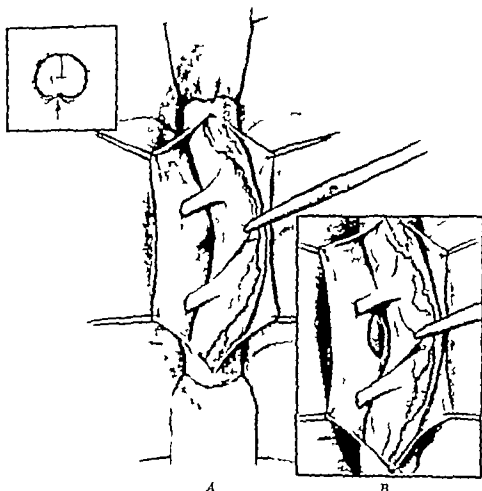


Fig. 208. Transdural exposure and removal of ventral chondroma. *A* The prominence exposed by incision of the dura and a slip of the dentate ligament and lateral rotation of the cord. *B* Incision of the posterior dura and exposure of the cartilaginous mass. Insert shows location of the mass. (Elaborated from the surgeon's sketch.) *(From Elsberg Surgical Diseases of the Spinal Cord Paul B Hoeber New York)*

1/6 or 1/4) and atrophine sulfate 0 45 mg (gr 1/150) The operation is occasionally attempted under local anesthetic, but as the nerve roots are approached it is usually necessary to give a short intravenous or general anesthetic

Formerly, a bilateral laminectomy was performed on all cases for the removal of the protruded disc but since localization of the lesion has become more exact a hemilaminectomy or partial laminectomy (only removing a small portion of the lower edge of the lamina above, and the upper edge of the lamina below) has proven quite adequate See pages 68-83 for Laminectomy Technics Occasionally it is possible to remove the protrusion without the removal of any bone The articular facets should be preserved in all cases to prevent further weakening of the vertebral column It is preferable not to open the dura but if radiopaque oil has been used it is necessary to remove as much of the oil as possible

Hemorrhage must be adequately controlled either by electrocoagulation or by gauze packs as a hematoma may produce symptoms identical with those of a protruded disc.

Recently less importance is being attached to the thickening of the ligamentum flava as a frequent cause of low back pain but the ligamentum flava which bridges the space between the laminae of adjacent vertebrae is often found thickened in cases of protruded discs and the ligament must be resected before the involved nerve root can be seen When the ligament is widely dissected, the oedematous nerve root can then be seen and retracted toward the midline revealing the protruded portion of the disc, which often can be removed by forceps alone However at other times the protrusion may be firmly attached to the nerve roots by adhesions and sometimes it is necessary to separate the attached side It is usually advisable to curette the opening in the disc gently to insure the removal of all loose particles and to prevent a recurrence of the symptoms

A supplementary bone graft fusion of the lumbar spine is necessary in certain cases when the operative procedure is extensive requiring the removal of a large amount of bone or when the articular facets are sacrificed This is often necessary in cases with a history of continued low back symptoms and weakness or when there is an excessive amount of motion of the lumbar spine noted at the time of operation It is also advisable for patients required to do hard labor

The graft should be inserted in all questionable cases at the time of laminectomy and all laminectomies should be so planned that a graft



Fig. 209-A This x ray picture illustrates a case of a female age 40 years with severe low-back pain which had been diagnosed as herniation of the intervertebral disc and a laminectomy was recommended by a prominent neuro-surgeon. Supplemental myelograms by Dr J Arthur MacLean's method failed to confirm this diagnosis but this roentgenogram with the accompanying schema shows a considerable diminution of the intervertebral disc between the fourth and fifth lumbar vertebrae with approximation of the posterior corners of these bodies and a marked diminution in the diameter of the intervertebral foramen and encroachment of osteophytic proliferation causing nerve root irritation.

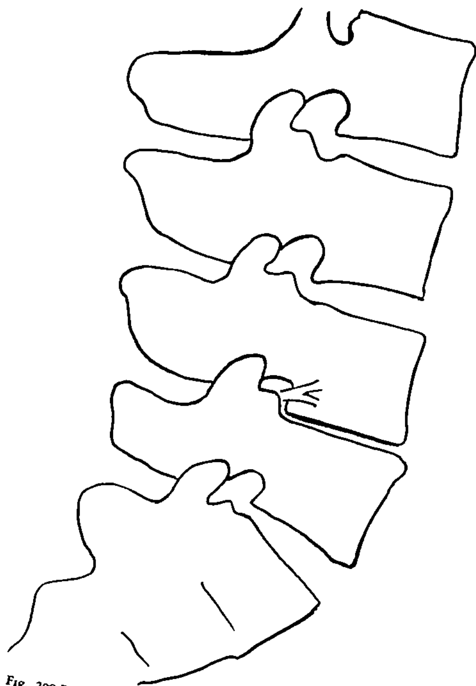


Fig. 209-B. Lateral view Albee schematic representation. Same case as Fig. 209 A.



Fig. 209-C. Postoperative x ray picture (same case as 209-A) showing fusion by tibial inlay graft and complete relief symptoms, one year after the operation.



Fig. 209-D Anteroposterior view Postoperative x ray picture (same case as 209 A and 209-C) showing graft in place and fusion which has relieved irritation of the nerve roots from the bony encroachment upon them [illegible] vertebral motion.

may be inserted at a later date, if necessary, for weakness or continuation of the low back symptoms The insertion of a bone graft does not increase the period of postoperative convalescence, but actually shortens the total period, nor does it prevent subsequent laminectomy if it becomes necessary for the removal of additional protrusions Casts and other supports are not necessary following bone graft fusion of the lumbar spine, and after three months the patient should be able to return to his regular occupation

Postoperative Care The postoperative treatment must depend upon the individual the severity and duration of the symptoms, and the extent of the operative procedure The patient is usually able to be dismissed from the hospital after two weeks but the usual period of convalescence is approximately three months Braces and other supports are rarely necessary, but gentle physiotherapy is often of benefit in relieving the muscle soreness

During the early days following the operation, the patient should be placed on a firm bed without any support and should be allowed to move his legs and to turn from side to side slowly, with the aid of an attendant He should be encouraged to move his toes and legs during the first few postoperative hours and his movements should be carefully watched to determine if any weakness has developed If any increase in the weakness of the movements of the lower extremities is noted hemorrhage should be suspected and the wound explored immediately

Catheterization of these patients is often necessary especially after the cauda equina has been manipulated which is often necessary for the adequate removal of some protrusion in the lumbar region Repeated catheterizations are not advisable and it may be necessary to insert an indwelling catheter but when this is necessary daily irrigations with boric acid solution and a prophylactic dose of 1 gm (15 grains) of sulfanilamide is advisable Allowing the patient out of bed to void on the second or third postoperative day is dangerous and is not considered justifiable

(If a bone graft has been inserted, see Chapter VI on Pott s disease for postoperative care)

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CHAPTER X

Osteomyelitis of the Spine

Osteomyelitis of the spine is an uncommon disease It has however received some attention in the literature, and as early as 1833 we find that numerous cases of perivertebral abscesses had been recorded by English, German and French authors In 1874 Delafield reported a case of acute osteomyelitis of the spine before the New York Pathological Society In 1903, Grissel found that only 85 cases had been reported in the literature

Incidence The acute pyogenic osteomyelitis of the spine occurs most often during the years when bone growth is most active that is when the secondary centers of ossification appear in the spine It is seen twice as often in males as in females Donati has reported that some 68 per cent of the cases were males and only 32 per cent females

Subacute and Chronic Types Although the subacute and chronic types of case are supposed to appear much less frequently than those with an acute onset, this is at variance with the authors own observation In their experience, quite a large percentage of cases have had a chronic course from the beginning

The age of occurrence in the subacute and chronic types is usually between the fourth and fifth decade of life

Etiology The organisms producing osteomyelitis are most frequently *Staphylococcus aureus*, *Staphylococcus albus* and *Streptococcus haemolyticus* However many other organisms have been found in isolated and rare instances to be the causative factor as for instance *Bacillus typhosis*, *Micrococcus tetragenus*, *Bacillus perfringens* Friedländer s bacillus, *Brucella melitensis* etc

There can be little doubt but that trauma plays a part quite often in determining the site of the infection Its chief significance lies undoubtedly in the fact that it produces an area of lessened resistance thus favor

ing colonization of the *microörganisms* Atsatt has reported a case of acute osteomyelitis of a vertebral body following compression fracture Fatigue, exposure, malnutrition and overexertion are other exciting causes In the majority of cases, the disease is of pyogenic origin, and usually follows infection elsewhere in the body

Clinical Findings The clinical symptoms depend upon the degree of involvement. Thus we find that in the milder cases where there is only a simple periostitis, fever, a mild degree of pain stiffness and local tender-



Fig. 210 Pyogenic osteomyelitis of the vertebral body The superior intervertebral disc is definitely thinned. The density of the body is well maintained. Male aged 14.

ness may be the only complaints In the severe cases the onset is sudden, with chills high fever vomiting and all the other manifestations of a severe acute infection The pain is intense at the site of the lesion in the spine Palpation reveals extreme internal pressure. It is not unusual to encounter large abscesses with cord and visceral complications with their attendant symptoms Referred pain is quite common

Pathology Osteomyelitis like Pott's disease, is seen most frequently in the mobile parts of the spine (lumbar spine) but it does occur however in the cervical and dorsal regions, and occasionally in the coccyx and sacroiliac joints The spinal lesion is quite similar (see x rays) to osteo-

myelitis in other parts of the body occurring as a periostitis of very mild course or as a periostitis and superficial osteitis of moderate degree or as a more virulent process with extensive bone destruction and abscess formation. A common pathological finding is slight wedge formation in the vertebrae and subsequent small gibbosity The pathological lesions in general vary, and may be localized primarily in the disc, or they may be of the destructive type and involve both the disc and the body of the vertebra The primary focus is usually in the cancellous bone marrow or in the disc.

In the subacute and chronic forms the pathological picture is quite often almost indistinguishable from Pott s disease

In the lumbar region, the psoas abscess is the one seen most frequently although an abscess developing in this region may extend along the crest of the os ilei

Diagnosis In the acute and fulminating type the diagnosis offers no great difficulty although occasionally the symptoms may resemble such diseases as typhoid fever, rheumatic fever pleurisy spinal meningitis etc. The local symptoms which develop however as swelling induration fluctuation and marked pressure tenderness usually serve to make the diagnosis clear

The type of lesion offering the greatest difficulty in diagnosis is that which occurs quite often in the subacute or chronic type and in which one or more bodies of the vertebrae are involved with only a slight elevation of temperature and little pain perhaps no more than a backache Many of these cases have been entirely overlooked or diagnosed as tuberculosis and the spine has even been fused on this basis

A correct diagnosis can most often be made however if one will make a careful analysis of the clinical data A history of preceding tuberculosis elsewhere in the body is of utmost importance in pointing to Pott s disease Likewise backache following pyogenic infection elsewhere in the body should lead one to suspect a similar infection if the x ray shows pathology Pain in osteomyelitis is usually much more constant and severe than in Pott s disease Kyphosis although it may be present is never as marked as in tuberculosis A *positive* blood culture rules out tuberculosis

Von Pirquet and Wassermann tests must be made in every one of these cases A basteriologic and microscopic examination, including guinea pig innoculation may be necessary to make the diagnosis Sedimentation rate is of little or no value.

X Ray Findings Anteroposterior, lateral and oblique views of the entire spine are important in diagnosing osteomyelitis of the spine. According to Kulowski, many of the most important and earliest roent genographic changes are noted in the anteroposterior views, particularly static deviations, periosteal calcifications, localized destructive vertebral body changes, alterations of the intervertebral spaces and proliferative changes of all kinds with varying degrees of bony bridging Other changes to be noted are sequestration, mottling of the vertebrae, and vary ing degrees of erosion and destructive phenomena. Spacial alterations in the early stages are the only indications of the most destructive phase of the disease in the intervertebral disc.

Unlike the early stages of acute osteomyelitis of the spine, in which he finds x ray examinations of little avail Steindler points out that in the early stages of chronic osteomyelitis x rays facilitate diagnosis by reveal ing the marked condensation of the bony structure—in contrast with the characteristic osteoporosis and atrophy of spinal tuberculosis

Prognosis The prognosis in the acute form is grave—the mortality being 45 to 50 per cent. In the subacute and chronic forms the outlook is infinitely better Death in these latter cases, when it does occur is usually from some such complication as the extension of an abscess

Treatment Surgery is required in almost all cases, and this is especially so in the acute and subacute forms of the disease where there is abscess formation Many of the milder cases, with no abscess formation respond to recumbency on a Bradford Frame or braceage treatment

Operation in acute cases consists of immediate free incision and drainage, with evacuation of the abscess through opening of all pus pockets in the vertebrae thorough removal of all dead bone and establishment of good drainage. In many cases the pus is deep seated and where the bodies of the vertebrae are involved it may be necessary to perform laminectomy or costotransversectomy to completely evacuate the pus

A large percentage of such cases will respond to an autogenous bac teriophage which can be injected through sterile catheters incorporated

in the paraffin vaseline gauze-packed wound or a solution of sulfonamide may be used If blood stream infection is present a specifically bred bacteriophage prepared with the vegetable asparagine as the vehicle should also be given intravenously The new drug penicillin may be of great value in these cases

In the occasional chronic type of lesion where spontaneous fusion of the vertebrae is prolonged, or does not occur, the use of a tibial bone graft fusion will often greatly shorten the convalescence B Koven has reported a series of cases in which fusion brought good results

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Spondylitis

(*Arthritis of the Spine*)

Spondylitis is an arthritic condition of the spine which is usually either a rheumatoid arthritis or an osteoarthritis Virchow was the first to pay much attention to spinal rigidities and his classification was undisputed until Von Bechterew in 1892 described several cases of spinal rigidity which he considered as an entity

Virchow in 1867 divided the cases into what he called *arthritis deformans* and *osteoarthritis* Those cases in which there was bone formation between the vertebrae with loss of tissue in the intervertebral structures he named *arthritis deformans* while those in which the ligaments were ossified he designated as *osteoarthritis* of the spine

The tendency at this time is to consider all cases of arthritis of the spine under two chief heads

1 Rheumatoid (atrophic arthritis) spondylitis
2 Osteoarthritic (hypertrophic arthritis) spondylitis.

This classification has been a great step forward toward a clarification and better understanding of all arthritis of the spine. Heretofore, many other spinal disorders have been frequently mentioned in discussions on spondylitis and this has been especially true of certain syndromes, which has added to the confusion For example there are many instances throughout the literature in which such syndromes as Marie-Strümpell disease a form of rheumatoid spondylitis have been discussed synonymously with Von Bechterew disease and again we find that Von Bechterew disease has been classified as an osteoarthritic spondylitis Likewise the condition known as spondylitis musculaire of Knaggs is in reality not a true spondylitis but is rather a kyphosis due to muscular weakness most likely of congenital origin It probably would be better for the sake

of clarity, at least from the clinical point of view if many of these terms were dropped.

Rheumatoid (Atrophic Arthritis) Spondylitis

Synonyms Spondylitis ankylopoietica spondylose rhizomelique, Marie Strümpell disease, spondylosis ossificans ligamentosa, Von Bechterew disease

Incidence This disease occurs most often in early adult life, and is much more common in males than in females In children it is occasionally associated with Still s disease, so that in conjunction with the spine involvement there is an involvement of many of the joints throughout the body together with a generalized lymphadenopathy and splenomegaly Where the disease occurs in the aged, it undoubtedly is merely an acute flare up of a condition which has been latent for many years.

Etiology As yet no definite etiological agent has been established for this disease However the pathology of the disease suggests an infectious basis throughout the body similar to that of rheumatoid arthritis and most authorities are of the opinion that infection is undoubtedly the prime etiological factor and that the spondylitis itself is secondary to some septic process elsewhere in the body such as septic foci about the bases of the tonsils or the teeth or a focus of infection in the gastrointestinal tract or the prostate gland or possibly as the result of some skin disturbance Traumatism by lowering the resistance may produce a locus minoris resistentiae and present a nidus of infection. Other indirect factors which may play a contributory role are individual susceptibility faulty metabolism improper diets and other similar influences

Symptomatology and Clinical Signs The onset of this disease is slow and is usually progressively chronic The symptoms in the beginning may be so mild that they may go unnoticed The complaint is usually stiffness followed by pain, due to muscle spasm or nerve involvement and is usually of the referred type The pain is located most often in the lower dorsal or upper lumbar level of the spine although it may be thoracic, abdominal sciatic, or neuralgic The symptoms may appear in recurrent attacks Buckley describes the 150 cases in which 12 per cent had an acute onset of the disease However in the majority of cases the

onset is slow and insidious, and in the great majority of cases the initial lesion as seen by x rays, is in the lower lumbar and sacroiliac joints The alteration seen consists mainly of a narrowing and gradual ossification of the joint space and as the disease progresses gradually there is calcifica

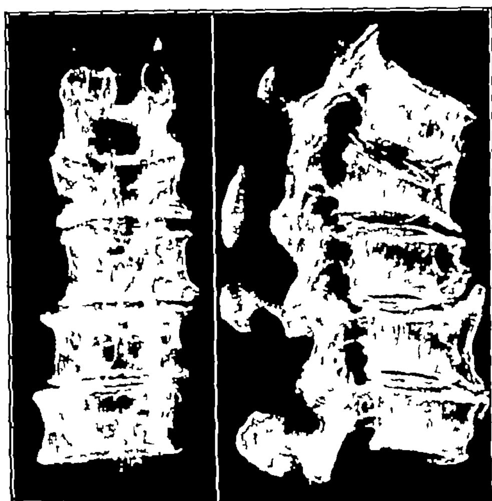


Fig. 211 Chronic osteoarthritis lumbar vertebrae of dried specimen. Name age and clinical history are unknown. There are well-developed marginal osteophytes on all five bodies, and those at the adjacent surfaces of 1 and 2 have fused together to form a strong bridge. The "small articulations" of the arches are not involved. The crushing of the body of 2 is presumably secondary to extrusion of material from the nucleus pulposus of the disk. *(From The Roentgen-Ray Diagnosis of Diseases of the Bones and Joints by P C Hodges D B Phemister and A Brunschwig—Thomas Nelson & Sons New York and Edinburgh 1938)*

tion of the spinal ligaments The deformity if any depends mainly upon the nature and extent of the changes in and about the vertebrae For example where there is destruction of cartilage without restoration of bone the straight stiff back is the rule In other cases there may be a

marked flexion deformity with ankylosis The cause of the deformity is essentially ossification of the ligaments These patients often appear worn and haggard, and in poor health Muscular wasting is frequently noted, and sensory disturbances are common.

Pathology The pathological changes may be essentially degenerative proliferative, or simply inflammatory without evidence of bone destruction Frequently the process is a combination of the three, depending however upon the resistance of the individual, and upon the virulence of the irritant Thus a proliferation of bone may occur in the form of exostoses which may gradually tend to fuse with each other And again atrophy of the cartilages may result, with or without bony replacements. The spinal ligaments, especially the anterior lateral ligament may undergo complete ossification There may be complete ossification of the intervertebral joints and portions or all of the spine may become fused Destruction and ankylosis of the intervertebral joints is a gradual process with gradual increase in the restriction of spinal mobility This is accompanied by rarefaction and softening of the intervertebral bodies

Diagnosis In those cases in which there is general involvement the clinical features presented offer little difficulty in diagnosis However in the early stages diagnosis is often quite difficult It must depend entirely upon clinical examination, and laboratory and roentgenographic evidence of the disease

Differential Diagnosis Rheumatoid spondylitis in its earliest stages in many instances, offers great difficulty to diagnosis and in the later stages of the disease, when x ray findings are demonstrable, there are other spinal disorders, such as other types of arthritis fracture malignancy tuberculosis and back injuries which must be differentiated from it

Treatment Discussion of the treatment will be found at the end of this section

Osteoarthritic (Hypertrophic Arthritic) Spondylitis

Synonyms Degenerative spondylitis, senile spondylitis

Etiology and Incidence The etiology of osteoarthritic spondylitis is in general the same as that of rheumatoid spondylitis Foci of infection faulty body metabolism and the mechanics, trauma and old age are all

important factors in its production Like rheumatoid spondylitis it occurs more frequently in males than in females, but it is much commoner than rheumatoid spondylitis, and occurs most often in individuals over 40 years of age, affecting the lumbar region more often than any other portion of the spine

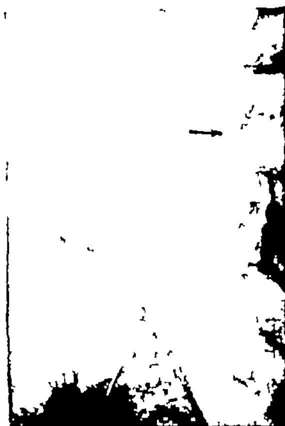


Fig. 212. Calcified iliolumbar ligament. This is degenerative calcification an indication of degenerative fibrositis. This condition has been mistaken for lumbar rib. There is minute lipping indicative of osteoarthritis in the lumbar spine (at arrows) Note the density and clarity of the minute calcifications. (*From Roentgen Diagnosis of the Extremities and Spine by A B Ferguson—Paul B Hoeber Inc., New York 1941*)

Clinical Features The disease may be asymptomatic but in almost every aged person some arthritic changes can be seen by x rays, and in many of these there may never have been any symptoms However when symptoms do occur, there is usually the complaint of pain and stiffness in the back. This is associated with muscle spasm Radicular or radiating pain is quite common, and especially so when there is involvement of the cervical spine, and the lumbosacral and sacroiliac joints The authors

opinion that many of the cases now diagnosed as low back pain due to intervertebral disc, nucleus pulposus and ligamentum flava disturbances can well be traced to a narrowing of the intervertebral spaces as a result of this disease, with consequent pressure upon the nerve trunk



Fig. 213. Dorsal round back with slight wedging. There is slight calcareous lipping at the articular margins anteriorly indicating secondary degenerative arthritis. Note that the calcareous lips have much the same sharpness and clarity as does adjacent normal bone although they may be partly or wholly amorphous. There is no reaction about the calcareous deposits. They appear inert. Female, aged 28. *(From Roentgen Diagnosis of the Extremities and Spine by A. B. Ferguson Paul B Hoeber Inc., New York 1941)*

passing out through the intervertebral foramen or in some instances to an osteophyte causing direct pressure upon a nerve trunk

It can readily be understood why an osteophyte on the posterior surface extending from the posterior margin of the body of a vertebra might cause pressure on a nerve trunk passing out of either the intervertebral foramen or upon the cord itself and never be diagnosed for osteophytes in such locations are almost impossible to see from x ray examination

Pathology Most of the pathological changes that accompany rheumatoid spondylitis may be observed in osteoarthritic spondylitis The intervertebral discs deteriorate and become thin, and a narrowing of the intervertebral spaces follows Spur formation and lipping occur at the margins of the vertebrae Quite often destruction of the affected vertebrae may occur with a secondary fibrositis Ankylosis seldom if ever occurs There may be an enlargement of the intervertebral articular processes with marked eburnation of bone

Diagnosis A diagnosis can usually be made following careful history and examination and x ray findings of lipping spur and osteophyte formations about the vertebral margins

Differential Diagnosis All the conditions discussed under rheumatoid spondylitis must be considered before a definite diagnosis can be made

Prognosis In both rheumatoid and osteoarthritic spondylitis the outlook for longevity is good Excluding cases of extreme nervous exhaustion the authors are of the opinion that about 40 to 50 per cent of these cases can resume their former occupations or at least some light work, following complete subsidence of the disease There is however, almost always some disability due to ankylosis of portions of the spine

Treatment The basis for the successful treatment of spondylitis of either the rheumatoid or osteoarthritic type, lies in a general knowledge of the patient s physical assets and liabilities and an accurate localization of existing foci of infection Having once definitely made a diagnosis, the treatment resolves itself into three parts

1 The thorough eradication of all primary and secondary foci of infection
2 The building up of all the body s natural defenses
3 Operative treatment

Eradication of All Foci of Infection Every effort possible should be made to eradicate all foci of infection which may be a contributing factor to the disease The thoroughness of this should be determined by repeated examination Quite often it is found that crypts of tonsillar tissue have been left after tonsillectomy or a tooth which apparently had been cured by palliative measures has an alveolar abscess which was never detected,

because x rays were not taken or an infected sinus may be incompletely treated, etc. In other words the more thorough the eradication of any focus of infection, the greater the chances of cure

The Building Up of the Body's Natural Defenses Since there is no specific for this disease and the greater part of the treatment is merely palliative the upbuilding of the native body defenses is of the utmost importance and should include the following therapy

1 Rest Fresh Air and Sunshine Rest in bed should be varied to me the idosyncrasies of the individual The patient should be kept in be during the painful stage of any form of chronic arthritis of the spine and until all discomfort in the infection region has disappeared Measures should also be adopted to prevent deformity If there is a tendency for a kyphosis to develop a position of hyperextension should be maintained The use of spinal supports such as a Whitman brace or a posterior plaster of paris jacket, is of great aid in preventing deformities.

Abundant fresh air and sunlight are of tremendous importance and, if it is at all possible, the patient should seek a warm climate where nature has provided these in the greatest abundance

2 Nutrition. The diet should usually be a generous one, with the caloric intake judged according to the nourishment of the individual. It should be of high vitamin content rich in fatty foods minerals, green vegetables and fruits moderate in protein content, and poor in carbohydrates It should include water milk, and buttermilk in generous quantities If at all possible it should be made up of foods which have been properly vitaminized and mineralized in their natural states If however such foods cannot be obtained vitamin substances such as cod liver oil viosterol or the standard capsules of Vitamin A, B D and E, should be taken

3 Environment Due to the mental condition of the patient, the environment should of necessity be a cheerful one both from the stand point of the people about him and of the physical surroundings in which he lives

4 Chemotherapy Tonics are of value, and should be used according to the patient s needs For patients suffering from anemia, liver extracts and iron will be found beneficial For cases with vitamin deficiencies, the

various appropriate foods plus vitamin preparations will prove valuable adjuncts to the treatment Salicylic acid compounds are often useful, and usually best given as sodium salicylate or aspiran, 0 3 to 0 6 gm (gr 5 to 10) with an equal amount of sodium bicarbonate Narcotics should always be avoided

Other drugs among the legion which have been used in the treatment of all types of arthritis are sulfur, gold salts, vitamin D, etc., all of which are of doubtful value Likewise sulfanilamide and its derivatives have as yet proved of little worth

5 Biological Preparations Thyroid extract is of value in the obese case which does not respond to diet The estrogenic hormones are of value in menopausal women

Venom. Cobra venom moccasin and bee venom are being employed quite extensively at the present time and are probably worthy of trial in conjunction with other therapy In continental Europe, bee venom (honey bee) and especially snake venom (*Vipera ammodytes*) have been found to have a marked analgesic effect, the latter more so than cobra venom Similar observations have been made in South America, where the venom of the cascabel is preferred to that of the cobra because of its absence of curare action The structure of the zoötoxins may be considered as basically the same, the active substance being a complex rich in sulfur with toxic enzymatic properties affecting the nervous tissues (neurotoxins) the coagulability of the blood the stability of the blood cells and the permeability of the vessel walls (hemotoxins)

6. Vaccine and Serum Therapy Autogenous vaccine and sera have proved of great value many times in the authors experience, and their opinion is that wherever a definite focus of infection can be found a culture and autogenous vaccine should be made In the preparation of these vaccines one must bear in mind that in many cases an arthritis may be started by one organism and then be continued by a secondary invader engrafted on the primary focus process and if an autogenous vaccine is to be of value in such cases it must be prepared not only from the primary infection, but also from the secondary and final infection The dosage of the autogenous vaccine varies from 10 000 000 to 2 000 000,000 killed organisms

One must remember, always that the best results from vaccine therapy are obtained only when accompanied by all the other therapeutic methods outlined.

7 Physical Therapy This is a most important part of the therapeusis. Following the acute symptoms some form of heat (wet or dry) applied locally usually gives marked relief In the less acute stages either short or long wave diathermy is of value, and should be applied three or four times weekly This is most effective when made an adjunct of Swedish massage. Hot baths too afford much comfort to the patient who can get into a tub

Exercises There is no doubt but that postural exercises and Swedish massage, preceded by diathermy are of great value as a daily procedure in the treatment of this disease Calisthenics should be planned to meet the individual requirements of each patient, and all exercises either passive or active, should be under the strictest supervision of a skilled mechanotherapist.

8 Deep X Ray Therapy From the observations of the authors, and from many recent reports, the results obtained have been so varied, that the value of this treatment is a matter yet to be proved.

Operative Treatment Although seldom necessary operative intervention in some instances where the pathological process is confined to a few vertebrae, serves to control the symptoms and the pathological process. Deformity once it has developed, is not possible to correct, but if the case is seen early enough progressive deformity can be largely prevented by means of fusion

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CHAPTER XII

Tumors of the Spine

The neoplasms of the spine are of either the benign or malignant type, with secondary metastatic tumors predominating in the latter group They are classified as follows

1 Primary Benign Tumors Of these, the following occur most frequently Osteomas osteochondromas, chordomas hemangiomas hydatid cysts and dermoids which are seen in connection with spina bifida occulta.

2. Primary Malignant Tumors Although there have been a few cases of primary carcinomas and sarcomas reported in the literature, the vast majority of primary malignant tumors are fibrosarcomas, endothe liomas and occasionally myelomas

3 Metastatic or Secondary Malignant Tumors These, in order of frequency are carcinomas sarcomas and myelomas

Incidence Schlesinger after an extensive analysis of 35 000 autopsies, found that 0 3 per cent of all tumors were of the spine, and that the majority of these were malignant As to bone metastasis Joll has reported (after careful statistical analysis) that 31 6 per cent of all bone meta stases are vertebral Thus we find that the majority of spine tumors are malignant, and the great preponderance of these are secondary meta static tumors. Not an infrequent number of these are direct extensions of gastric and oesophageal neoplasms The dorsal and lumbar regions of the spine are predilective sites for cancer and one or several vertebrae may be involved The development is by independent metastasis, which occurs most frequently in the body of the vertebra, near the center and spreads outward toward the periphery and ultimately may involve the arches laminae and spinous processes. The primary organs of localiza tion giving rise most often to these tumors are in point of frequency the breast, the thyroid, the uterus, the gallbladder and the prostate gland (Steindler)



Fig. 214 Hemangioma of vertebrae. (Reported from the University of Chicago Clinics by Bucy and Capp) (*From the Roentgen-Ray Diagnosis of Bones and Joints by Hodges Phemister and Brunschwig—Thos Nelson and Sons New York and Edinburgh 1938*)

Pathology The consensus and there is a preponderance of evidence to substantiate it, is that bone metastasis is blood borne and the result of malignant emboli in the marrow capillaries The older theory that tumor masses are propagated in bone by the lymphatic system is open to grave doubt.

Pathology of Individual Tumors PRIMARY BENIGN TUMORS 1 Osteomas and Osteochondromas These are the most frequently seen benign tumors of the spine The osteomas are composed of spongy, eburnated bone and encapsulated with fibrous tissue They may occur in any part of the spine The osteochondromas or exostoses are not infrequently found in the spine They occur most often between the ages of 10 and 25 years Microscopically these tumors are composed of normal laminated bone beneath a transitional calcifying cartilage Surrounding this is a layer of fibrous tissue

The symptoms of both osteomas and osteochondromas are usually mild and of long duration. They require no treatment if they are symptomless

2 Chordomas These tumors arise from remnants or rests of the embryonic notochord and are found most often in the clivus blumenbachii and sacrococcygeal region They are quite rare and occur slightly more frequently in males than in females The production of mucus is the most important characteristic of notochordal tumors

3 Hemangiomas These tumors are quite rare Smith in reviewing the literature found only 29 cases had been reported in which diagnosis was arrived at before necropsy He is of the belief that many hemangiomas of the vertebrae are mere anatomical anomalies of the venous channels Most often they involve only one vertebral body

4 Hydatid Cysts (Echinococcus Cysts) According to Frey these metastatic hydatid cysts occur in only 1 5 per cent of the cases Most of these tumors are slow of growth, and tend to [illegible] d invade not only the osseous tissue but also the surrounding [illegible]

Bland Sutton has reported three r[illegible] pes (*a*) wh[illegible] cyst arises from the vertebrae and ext[illegible] al (*b*) w[illegible] cyst is locat[illegible] nal either in[illegible] or between and the bon[illegible] tissue (*c*) [illegible] begins in structures [illegible] the spine [illegible]

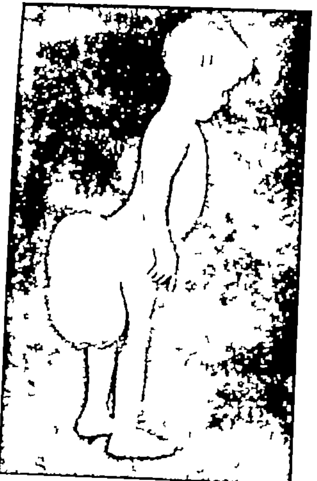


Fig. 215-A. Dermoid cyst at the sacral region. Such a tumor may cause confusion with a neoplasm of vertebral of sacral origin. (Author's case.)



Fig. 215-B Same case as Fig. 215-A—shows child's habit of always sitting on the tumor which was so large that it served for this purpose very well

5 Dermoids These are very rare tumors of the spine and are usually found in connection with spina bifida Quite rarely they produce pressure symptoms on the cord



Fig. 215-C. Same case as Fig. 215-A—after removal of tumor Excellent cosmetic result. (*From Orthopaedic and Reconstruction Surgery by F H Albee W B. Saunders Co., Philadelphia and London 1921*)

PRIMARY MALIGNANT TUMORS 1 Carcinomas and sarcomas very seldom attack the spine as a primary tumor

2 Primary Osteogenic Sarcomas. Although of very infrequent occurrence a few cases of primary osteogenic sarcoma have been described in the literature Their chief significance lies in the fact that they may be mistaken for Pott s disease However in sarcoma, there is a more rapid

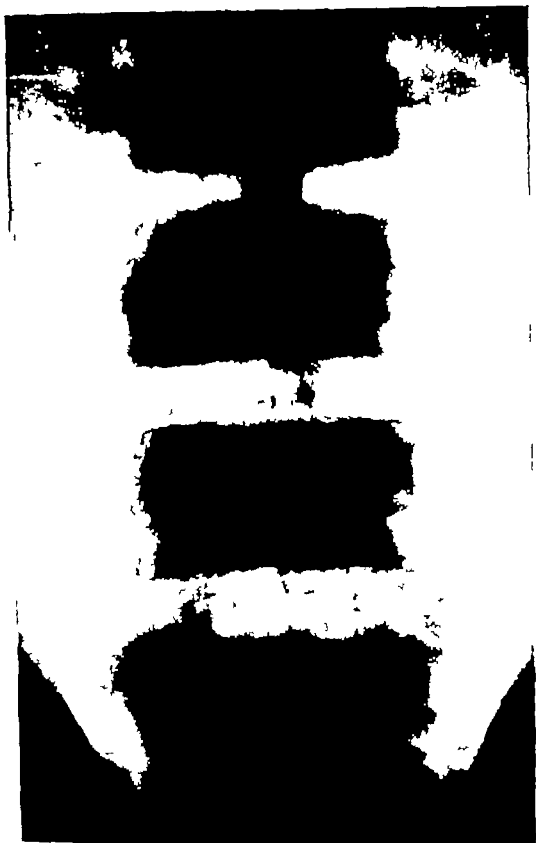


Fig. 216. Dense condensation in vertebrae of metastases of prostatic carcinoma (*From Roentgen Diagnosis of the Extremities and Spine by A. B Ferguson—Paul B Hoeber Inc New York 1941*)

destruction of the vertebral body than in Pott s disease, with, usually little involvement of the adjacent discs. Cord symptoms may appear early

3 Primary Giant Cell Sarcomas Only a few cases have been reported in which this type of tumor has occurred as a primary one in the spine. Roentgenographically, such tumors simulate Pott s disease in many respects. Microscopically the tissue shows many large, round and spindle cells polymorphism, scattered giant cells and nuclear hyperchromatosis



Fig. 217 Localized areas of increased density Osteoplastic metastatic lesion. Primary site prostate. *(From Diseases and Deformities of the Spine and Thorax by A. Steindler—C V Mosby Co., St. Louis 1929)*

4 Chloromas These tumors are closely related to sarcomas and in reality are a neoplastic disease of the hematopoietic system. Some pathologists consider them to be a form of myelogenous leukemia Their clinical course is very similar to acute lymphatic leukemia They spread not only through bone but metastasize hematogenously

5 Multiple Myelomas Multiple myelomas are usually characterized by multiple foci of origin, although there have been a few cases of solitary myeloma reported. An osteolytic tumor of the hematopoietic bone marrow origin it occurs most often during middle or advanced age There

are at least three distinct histologic types of this tumor, namely, the myelolytic, lymphatic, and plasmocytic The bones most frequently involved are the ribs, the vertebrae the sternum etc

Pathologically, this tumor is a specific malignant one of the bone marrow, and has a specific structure of plasma cells or their derivatives The x ray picture in the vertebrae shows a blurring melting away, and col



Fig. 218-A. Multiple myeloma with deformity of chest. Case of Dr Charles A. Parker

lapse of the vertebral bodies involved Pathologic fracture may occur and although the original tumors are confined to the bony system metastasis to other organs does occur

The presence of Bence Jones protein in the urine usually means multiple myeloma. However it is quite often absent during the course of the disease, and is also sometimes present in the urine with other tumors Thus in the end its real diagnostic importance is only that of one link in a chain leading to accurate diagnosis

The prognosis of multiple myeloma is very discouraging X ray therapy has little effect on the course of this disease



Fig. 218-B. Rarefied and collapsed spine in the case shown in Fig. 218-A. *(From The Roentgen-Ray Diagnosis of Diseases of Bones and Joints by Hodges Phemister and Brunschwig—Thos Nelson & Sons N Y., and Edinburgh 1938.)*

METASTATIC AND SUNDRY MALIGNANT TUMORS OF THE SPINE 1 Carcinomas Metastatic or secondary carcinomas are commoner in the spine than secondary sarcomas and are seen less frequently in men than in women in whom they are due to metastasis from the breast and uterus



Fig. 219 Marked wedging of D-10 The spinous processes are not widely spread. Each cortical surface and disc is intact. No portion of the disc is depressed into the body In compression, the substance of the vertebra is still present. It is squeezed out anteriorly Here the detritus anteriorly is not continuous with the body and is not sufficient to represent the absent vertebral substance. The substance is gone. There is no compression area in the remnant. In fact, density is decreased. This is wedging following destruction. There is no reaction area or cortical decalcification. The lesion is metastatic carcinoma. Female aged 55 *(From Roentgen Dagnosis of The Extremities and Spine by A. B. Ferguson—Paul B. Hoeber Inc., New York 1941)*

Carcinomas metastasize to the spine from the breast uterus and prostate in the order given, more frequently than from any of the other organs Several vertebrae usually are involved and these are generally in the lumbar and dorsal regions Carcinomas can rarely be palpated or a diag nosis made, except in those cases in which the spinal nerves are com pressed, and in which bony displacement and cord symptoms arise during



Fig. 218-B. Rarefied and collapsed spine in the case shown in Fig. 218-A. *(From The Roentgen-Ray Diagnosis of Diseases of Bones and Joints by Hodges Phemister and Brunschwig—Thos Nelson & Sons N Y and Edinburgh 1938.)*

paris cast sometimes gives some relief Roentgen therapy, although not a cure, is of value in many instances because it often relieves the neuralgic and root symptoms, and consequently should always be given a trial either alone or in conjunction with operation A number of cases have been reported in which patients have lived several years after repeated roentgen

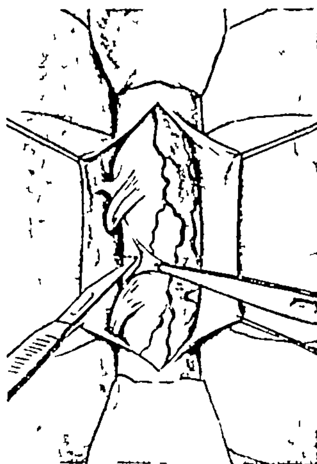


Fig. 220 Laminectomy Section of the left anterolateral tract the cord is rotated by forceps grasping the cut end of the dentate ligament. The location of the incision is shown by a broken line. (Enlarged to show details.) *(From Elsberg, Surgical Diseases of the Spinal Cord Paul B Hoeber New York)*

treatments and this is especially so in Hodgkin s disease with extradural masses and sarcomas However it must be realized that in the main the results of present-day roentgen and radium therapy have been far from good

Operative Treatment Radical operation is seldom of any value in the treatment of spinal tumors Occasionally however a benign tumor can

the course of well-defined new growths elsewhere. Roentgenographically, the earliest changes seen are in the outlines of the involved vertebrae This stage is followed by the gradual signs of deformation as the lesion progresses Ossifying metastasis of a carcinoma may occur in the spine following carcinoma of the prostate and is often mistaken for spondylitis deformans Metastatic hypernephromas to the spine have been reported in the ossifying form.

2 Sarcomas Sarcomas develop in the bone or periosteum and usually cause softening of the vertebral body involved. The erosion may become so great that the superincumbent body weight gradually forces the two intervertebral discs together This settling, as it is called, causes the most intense pain The diagnosis can be made more readily in sarcoma than in carcinoma because of the tendency of the former to grow beyond the limits of the initial lesion

A few cases have been reported in which metastatic growths in the vertebrae and vertebral canal have been found to be composed of normal thyroid tissue Some authors believe these growths to be misplaced thyroid rests , others think they are of true metastatic origin The clinical course is not significant the diagnosis usually is made following operation for signs of cord compression. Most of these patients received complete relief of their symptoms following the removal of the extradural growths and the institution of roentgen therapy

A very rare secondary lesion of the vertebrae which may cause cord symptoms is aneurysm of the aorta. Shimkin (1938) found some 46 such cases with erosion of one or more vertebrae

The diagnosis can usually be made from the patient s history and by x ray and fluoroscopic examination. The prognosis is poor the outcome usually being fatal in only a few months Antisyphilitic therapy is of no value.

In general the symptoms of spinal tumors are pain and deformity the great majority of the cases complaining of neuralgia and radicular pain from pressure on the nerve roots and cord The deformity most frequently seen is a rounded kyphosis

Treatment. *Palliative Treatment* In by far the majority of cases, the treatment of spinal tumors is purely symptomatic, the chief aim being to relieve the symptoms of pain and pressure For this reason a plaster of

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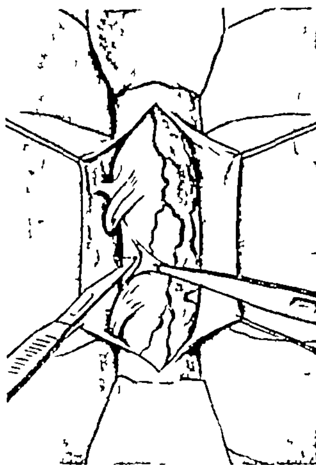


Fig. 220. Laminectomy Section of the left anterolateral tract the cord is rotated by forceps grasping the cut end of the dentate ligament. The location of the incision is shown by a broken line. (Enlarged to show details.) *(From Elsberg Surgical Diseases of the Spinal Cord Paul B Hoeber New York)*

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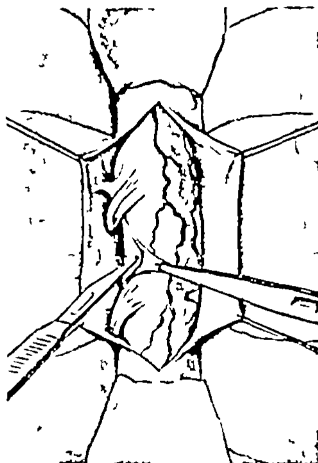


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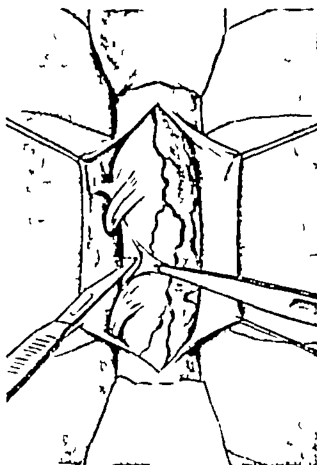


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Operative Treatment Radical operation is seldom of any value in the treatment of spinal tumors Occasionally however a benign tumor can

be removed with success In cases where there is excruciating pain, relief may be obtained by paravertebral injections of alcohol or by chordotomy

Chordotomy was first proposed by Spiller and first performed by Edward Martin in 1911 It consists of the division of the anterolateral

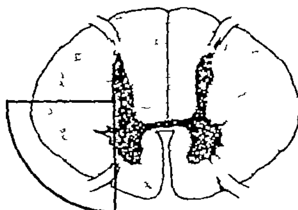


Fig 221 Transverse section of the spinal cord showing the area involved in section of one anterolateral tract (diagrammatic) *(From Elsberg Surgical Diseases of the Spinal Cord Paul B Hoeber New York.)*

tracts on one or both sides According to Elsberg this operation should be performed only on patients whose life expectancy is at least several months

In a few instances to alleviate the pain of patients dying from malignant vertebral tumor the senior author has used a tibial bone graft inlay to immobilize the involved vertebrae In some cases the relief obtained has been remarkable However this procedure is rarely justifiable

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Miscellaneous Affections of the Spine

Vertebral Osteochondritis

Osteochondritis of the spine is a rather rare infection and its etiology is obscure. It usually develops first during the early years of life being

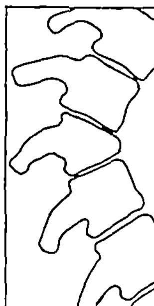


Fig. 222. Vertebral osteochondritis Note marked wedging of single vertebral body (Tracing from roentgenogram.) *(Shand's Handbook of Orthopedic Surgery C V Mosby Co)*

most common between the ages of 5 and 10 It occurs most often in the lower dorsal and lumbodorsal levels of the spine Pathological changes are usually localized in a single vertebral body

Clinical Features Vertebral osteochondritis is characterized by moderate or very slight pains night cries rachitic muscle spasms, and tenderness Deformity is evident as a kyphosis and occasionally scoliosis Roentgenographically there is an irregularity of the vertebral outline and the body of the vertebra may show evidence of splitting or fragmenta

tion. The vertebra becomes flattened and wedge shaped. This is followed by the reparative stage in which the vertebral outlines appear dense and sclerosed and the intervertebral spaces appear normal or are widened, in proportion to the amount of thinning of the vertebral bodies

Diagnosis This disease must be carefully differentiated from tuberculosis of the spine which it may closely simulate. The literature is full of instances of vertebral osteochondritis which were first diagnosed as Pott s disease, and treated as such Confusion with vertebral epiphysitis is another diagnostic pitfall to be guarded against In vertebral epiphysitis *the changes involve several vertebrae*

Treatment In cases with progressive or marked deformity the splinting of the spine with a tibial bone graft is the treatment of choice. The kyphosis in most instances can be corrected by hyperextension on the operating table, and the bone graft inlay is inserted while in this position. However in the most severe deformities preoperative correction by a turnbuckle plaster cast may be necessary Adequate internal immobilization can be obtained by including only one vertebrae above and below the lesion, as the vertebral body in this condition does not tend to collapse. Weight bearing is permitted within seven weeks and no cast is required The bone graft serves two purposes It acts as an internal splint to prevent recurrence of the deformity and it aids in creating an increased blood supply by bringing blood from above and below through the graft to the cancellous systems of the involved vertebra and thus helps restore a more normal nutrition to the affected bone.

The authors are of the opinion that it is highly important that a case *severely and locally affected be returned to full activity as soon as possible,* and for this reason the tibial bone graft is especially favored, as it eliminates the long period of convalescence required in the use of braces a matter of two or three years in some instances

Vertebral Epiphysitis

This condition has been described by Buck as a self limiting affection, involving the epiphyses of the spine and occurring most commonly in the dorsal region. It is a chronic affection of the epiphyses of the vertebral bodies and always involves a number of contiguous vertebrae. It occurs

most often between the ages of 10 and 21, and usually runs its course in two or three years Its etiology has not been definitely established

Clinical Features The onset of this disease is usually associated with the sensation of fatigue and backache and pains in the limbs There is tenderness over the spinous processes and there may be tenderness over the lumbar vertebral bodies upon abdominal palpation The deformity



Fig. 223-A. Vertebral epiphysitis. Note round back.



Fig. 223-B Lateral x rays of patient in Fig. 223-A. Note fragmentation of epiphyses. *(From Diseases and Deformities of the Spine and Thorax by A Steindler—C V Mosby Co., St Louis 1929)*

which occurs is the disturbing factor and is developed secondarily It may be a kyphosis or it may be a scoliosis In many instances the patient may be found to be almost asymptomatic or having such slight symptoms as to attract little attention the deformity being the first thing to be noticed.

Diagnosis This condition must be distinguished from tuberculosis of the spine and from osteochondritis In tuberculosis there is usually more severe pain and a more marked rigidity of the spine and x rays usually reveal localized bone destruction which is not present in epiphysitis The

chief distinctions between vertebral epiphysitis and osteochondritis are the facts that osteochondritis usually develops at an earlier age and is localized most often in a single vertebra, instead of several The x ray *furnishes the final means* of differentiation

Treatment The type of therapy used in the treatment of this condition depends almost entirely upon the severity of the symptoms In the milder cases all that may be necessary is proper physiotherapy (massage and muscle stretchings and training) in conjunction with some type of spinal support, such as a Taylor brace or plaster jacket However, in the more severe localized cases, it is the author s opinion that a tibial spine graft *fusion is the best possible method of treatment, and the quickest means of* achieving early rehabilitation

Posttraumatic Kyphosis

Traumatic Spondylitis (Kümmell s Disease)

This clinical entity was first described by Kümmell in 1895 It is a non-tuberculous rarefying osteitis of the vertebral bodies and is a chronic affection of the adult spine characterized clinically by the delayed development of a deformity following trauma, and pathologically by rarefaction and collapse of the affected vertebral bodies The softening and collapse of the vertebral bodies give rise to deformities which are not unlike Pott s disease Either a single injury or repeated injuries may be the positive agent. An important contributing factor is the low degree of reparative potentiality of vertebral bone in general Schmörl s work *corroborated experimentally by Compere and Keyes has shown that the* collapse of the vertebral body is due to a leakage of the nucleus pulposus material through a tear in the intervertebral disc, and the formation of a non-ossifying cartilaginous mass in the bodies of the vertebrae involved The vertebrae from the third to the seventh dorsal are usually affected, although the lumbar and cervical vertebrae may also be attacked

Clinical Features There is usually a history of injury followed in a day or two by the subsidence of the immediate symptoms Following this the patient may be free of symptoms and may be able to resume his ordinary occupation and then after days weeks and even months, the patient begins to notice some discomfort and even deformity The most

outstanding feature is the development of a kyphosis located in the dorsal spine There may be continued weakness and considerable pain in the muscles of the back and lower extremities and in some cases there is marked low back pain

Diagnosis Unrecognized compression fracture of the vertebral bodies and tuberculosis should be considered in the differential diagnosis X ray evidence is final

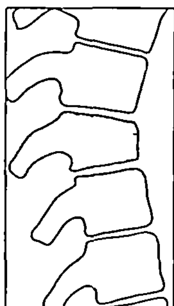


Fig. 224. Posttraumatic kyphosis (Kummell s disease.) Note moderate wedging of single vertebral body (Tracing from roentgenogram.) *(Shand's Handbook of Orthopedic Surgery C. V Mosby Co)*

Treatment The prognosis is good, and especially is this so when no neurological symptoms have developed The best results are obtained by immobilization of the spine preferably in hyperextension, with a plaster jacket for a period of about a year However in the more severe cases the Albee operation for spine fusion as done for Pott s disease and described on page 185 is undoubtedly the treatment of choice as it not only relieves the patient of his symptoms but also decreases the time required for his recovery

Traumatic Neurosis of the Spine

(Railway Spine, Neurotic Spine, Functional Spine)

Traumatic neurosis consists primarily of a functional disturbance of the nervous system without demonstrable lesion of the spine or spinal

cord, and is most often dependent upon some railroad or other accident. There can be little doubt that some injuries of the back are followed by generalized aches and pains over the entire body, and that the symptoms which follow sometimes undermine the patient s psychic stability and lead to the development of a frank neurosis There may be a sprain of a lumbar muscle, but without anatomical disturbance of the spine or spinal cord and the chain of symptoms ensuing is quite often due simply to auto suggestion from the mental image of the accident A medicolegal relationship should not be forgotten as an etiological factor A few cases have been reported in which persons have extricated themselves from a wreck, assisted in giving aid to others walked a considerable distance and then collapsed gradually without manifesting any sign of physical disturbance of the spine or spinal cord

Clinical Features This condition is commoner in female adults of the nervous or neurasthenic type than in males, although in many instances the symptoms appear to be the direct result of slight injury Usually pain and aching are present throughout the back and neck, and quite often the discomfort is localized about a prominent spinous process, most often near the vertebra prominens There may be hypersensitiveness of this region, and of other areas over the spine. The symptoms however are entirely subjective and inconstant changing from day to day and producing no muscle spasm or limitation of motion There is no pain at the peripheral distribution of the nerves as in tuberculous kyphosis, although patients suffer much with backache, and tire easily The symptoms are nearly always more marked when the element of compensation or litigation is present, and many of these patients are only cured after the damage suit is settled

Diagnosis The diagnosis of traumatic neurosis requires great care for it is necessary to exclude all possibilities of any organic lesion. The patient s past history and psychic state of mind are of invaluable assistance in making the diagnosis

Treatment The most important therapy is effective psychotherapy However, the treatment should include tonics general attention to the hygiene, rest, and local physical therapy such as massage, diathermy, etc Often it is helpful to have the patient wear some sort of a back support, either in the form of a corset or brace Postural exercises are

of definite value and should by all means be included in the treatment Any abnormalities of the feet or knees should be corrected

Coccygodynia
(Coccyodynia)

Coccygodynia is a painful condition in the region of the coccyx It is commoner in females than in males In the more severe cases there is quite often a history of a blow such as striking on the end of the spine on some occasion It may also be brought on by long continued horseback riding and other similar activities

Clinical Features In some cases no cause can be found and no lesions of the coccyx discovered The coccyx, if displaced is usually displaced either forward backward or laterally In some cases a nodule from overgrowth of bone is found on the tip or side of the coccyx and pressure at this point causes severe pain Walking defecation or riding over rough pavement usually increases the pain Finger pressure in this region elicits severe pain which is referred to the fifth sacral and coccygeal nerves The contour and position of the bone are readily ascertained by x ray and external and rectal examination Patients suffering from coccygodynia are apt to be highly neurotic

Treatment Every means should be attempted to build up the general health of the patient The bowels should be kept well open and the patient advised to sit on an air cushion or forced to lie on the side for a few weeks If there is a displacement of the coccyx this can usually be corrected by manipulation High frequency electricity applied by means of a special electrode has been found efficient in most instances by the author Hydrotherapy consisting principally of the Scotch douche on the back, is often effective The injection of novocain and saline solution in and about the coccyx, is reported by others of the profession as bringing beneficial results

If however the symptoms do not subside under conservative treatment, and there are evidences of pathological changes in the bones from trauma or disease an operation in which the whole bone or a portion of the bone is excised is recommended Every precaution however should be taken to avoid operating on a neurotic patient

Technic of Coccygotomy The incision should be made near the midline, and the dissection should be kept close to the bone so as to avoid injuring the sacral and coccygeal nerves When the fascia is removed from the tip of the coccyx, the anus becomes somewhat dilated because of the attachment of the external sphincter muscles to this bone. This patulous condition can be overcome and the anus restored to the normal appearance by placing deep sutures from the periosteum of the sacrum to the tendinous portion of the external sphincter After the operation the legs should be fixed together and the patient directed to lie upon the side Cathartics are given on the third or fourth day and the patient is allowed to be up and about after a period of from 10 to 15 days

Typhoid Spine

Typhoid involvement of the spine is not common. According to Gaul, it occurs in only about one out of 1800 cases of typhoid fever Attention was first directed to this condition by Gibney in 1889 It occurs usually at about the age of 20 and is much more common in males than females It attacks most often the lower dorsal and upper lumbar regions of the spine

Clinical Features Typhoid infection of the spine is usually associated with pain as a constant symptom which is aggravated by movement Referred pains are not unusual There is usually a marked rise in body temperature with local swelling redness and tenderness Spinal rigidity and kyphosis as well as cord symptoms may be present The cord symptoms may be merely irritative or may result in complete paralysis Roentgenographic examinations usually show involvement of the intervertebral discs, with possible bone proliferations along the bodies and on either side of the vertebral space (see Figs 225A and 225B) This is the result of periostitis and osteitis Punched out areas in the vertebral bodies have been observed by the author in several cases

Diagnosis This is usually not difficult Typhoid fever and its attendant symptoms usually precede this condition The Widal test is almost always positive Typhoid bacillae have been found by the authors in the blood, urine, and bile

Treatment The prognosis in these cases is good. The lesions rarely progress to pyogenesis. In the treatment of this complication of typhoid



Fig. 225-A.



Fig. 225-B.

Figs. 225-A and 225-B. Lateral and anteroposterior roentgenograms of the lumbar spine showing a destructive process (typhoid) between the second and third lumbar vertebrae with involvement of the disc and left scoliosis. *(Journal of Bone and Joint Surgery Vol 20 April 1938)*

fever, therapy is almost entirely symptomatic Immobilization of the back by means of a plaster cast or shell is indicated and quite often relieves the intense pain However even with rigid immobilization the pain sometimes becomes extreme In some cases however where the lesion remains active, the advisability of immobilizing the affected segment of the spine by an inlay bone graft as applied in Pott s disease has been found effective When abscess formation takes place and it becomes necessary to drain it, the authors believe that the treatment of choice is to make a culture and a specific bacteriophage and to introduce this both locally and intravenously This method has been employed by the authors in treating both typhoid bone abscesses of the spine and of the long bones The procedure is this After the abscess has been incised the wound is packed with gauze saturated with a compound consisting of paraffin 90 per cent and yellow vaseline 10 per cent mixed at a temperature of 37.8° C. (100° F) The specific bacteriophage which has been bred in the laboratory is then employed locally and intravenously This procedure offers an excellent means of attacking typhoid disease of the spine and this is especially so when the specific bacteriophage can be obtained although a stock bacteriophage may be employed intravenously in cases where surgical drainage has not been instituted

The best results in the use of bacteriophage have been in those cases where a definite febrile reaction is obtained by the patient following its administration In one case a check of the bile urine stool and blood was made for *B typhosis* two months after the initiation of this treatment, and all proved negative although they were previously positive for *B typhosis*

Occasionally the condition may become chronic If so and the patient s general condition is good and the progress of spontaneous fusion between vertebrae is retarded spinal fusion with a tibial inlay graft will shorten the convalescence considerably and prevent long disability from continued backache

Gonorrheal Spine

Gonorrheal infection of the joints is not infrequent but gonorrheal infection of the spine is quite rare even more rare than typhoid disease of the spine

Clinical Features Symptomatically, gonorrheal infection is quite hard to differentiate from any other active spinal condition although the diagnosis can usually be made safely in the presence of spinal pain and stiffness following chronic urethritis This is especially so if other joints are involved, and if a gonorrheal fixation test is positive. The spine is most often stiff and a tendency to ankylosis is the rule There have been cases reported in which gradual ankylosis followed gonorrheal disease of the spine extending from the sacrum to the occiput

Treatment In the treatment of gonorrheal disease of the spine, it is of the utmost importance that the primary focus in the genitourinary track be eliminated first Chemically, sulfathiazole and other drugs of this group have given good results in this connection. Local treatment consists of rest in bed, preferably on a Bradford Frame for support of the spine plus local application of heat and cold. Usually an ice bag affords great relief Vaccine is of a debatable value. The recently introduced *snake venom is of some value in this connection.*

After the subsidence of the acute symptoms a plaster of paris jacket is indicated, and should be continued as long as active symptoms persist. This however may be supplanted by a spinal brace or a graft fusion, *if necessary A fusion may be indicated at the upper dorsal region if the* development of a kyphotic deformity cannot be prevented otherwise.

Syphilis of the Spine

Syphilitic lesions of the spine, although not unusual in children, are rather rare in adults. The principal syphilitic lesions of the vertebrae are localized periostitis and osteochondritis Gummatous lesions rarely, if ever are primary in the vertebrae Nodes and caries from extension of a syphilitic ulcer are seen *occasionally Although all regions of the spine* are susceptible, the cervical region seems to be the one most frequently attacked This is due probably to its proximity to the pharynx, from which it acquires its syphilitic involvement as a matter of extension. All the component parts of the vertebrae bodies intervertebral discs ligaments, transverse and articular processes, may be involved

The syphilitic lesions of the spine differ in no respect from the manifestations of the disease in other joints although it may be difficult to

make an accurate diagnosis because the condition is quite frequently associated with tuberculosis Since the disease produces periostitis and hyperplasia rather than degeneration the compression thus caused about the nerve roots produces pain which is often very distressing Abscess formation is not common



Fig. 226. Charcot Spine. The frontal view of the lumbar column in a living subject thirty years after primary infection and two years after cord symptoms were first noted. Note the curvature deformity of vertebral bodies, osteophyte production, and subcortical sclerosis particularly in L4 and 5 *(From The Roentgen-Ray Diagnosis of Diseases of Bones and Joints by Hodges Phemister and Brunschwig—Thos Nelson & Sons 1938 New York and Edinburgh)*

Clinical Features The clinical manifestations of this condition are pain (worse at night) dyspnea dysphagia (from pressure) and rigidity The deformity quite often simulates that of Pott s disease from which it must be distinguished When spondylitis occurs in children under three years of age, and is associated with other chronic joint lesions it is usually syphilitic rather than tuberculous Further the history of syphilis in the past hutchinsonian teeth nasal catarrh suppurative otitis

and interstitial keratitis should all aid in distinguishing between the two X ray examination and a Wassermann test should confirm the diagnosis

Occasionally syphilitic aneurysm of the aorta attacks the adjacent vertebrae, and these may become involved in the inflammatory mass. In most cases of tabetic osteo-arthropathies it has been found that the vertebral bodies are thickened with extensive arthritic development. Ankylosis and ossification of the ligaments may occur The spinous processes are thickened and roughened Spontaneous fracture of the involved bones is common, and pain is of less consequence to the sufferer than the disturbances of locomotion.

Treatment The treatment of spinal syphilis is mechanical and medicinal that is, rest, spinal support in the acute stage, and supplementary treatment by the various antisyphilitic drugs This treatment should be continued for a period of from 18 months to two years and further observation for at least five years

In some cases where the symptoms persist the bone graft fusion, as applied by the authors in Pott s disease, may be used in conjunction with anti syphilitic treatment as an immobilizing measure This is especially so in Charcot spine where there may be a softening of the vertebral bodies A case in point is that of a young woman with a marked kyphosis of the dorsal region, with severe symptoms associated with lesions of the jaw and sternoclavicular joint. Following the insertion of a tibial bone graft, her spinal symptoms were immediately and entirely relieved, although at the same time the lesions in the jaw and sternoclavicular region resisted the most strenuous anti-syphilitic treatment for a long time

Lesions of the Vertebrae in Undulant Fever

W A Bishop Jr has stated that localization in the spine is the commonest bone and joint complication of undulant fever This localization usually occurs during convalescence All three subspecies of the Brucella group abortus melitensis and suis have been cultured from the local lesions It however is unnecessary to distinguish between them as the clinical course is identical in all three

Clinical Features Most reported cases of undulent fever spondylitis have occurred in the lumbar region There are no comprehensive patho-

logic reports from human cases, but Feldman and Olson, after an extensive study of the vertebral lesions in hogs, have reported that the pathological process seemed to originate in the epiphysis and form irregular abscesses in the vertebral bodies and intervertebral discs These small lesions contained a grayish white pasty or cheesy material, and occasionally a sequestrum Certain of the lesions presented a crescent shaped caplike inflammatory proliferation of osteogenic tissue bridging the intravertebral space on the ventral surface of the affected vertebrae. From their studies Feldman and Olson concluded that the amount of ossification is variable, depending on the duration of the lesion Their gross description of these lesions in hogs appears to be compatible with the roentgen picture observed in human cases

The spinal complications can be divided into two types those which are acute and those which are chronic in form The acute form assumes the character of acute osteomyelitis with suppuration occasional abscess formation and eventual fusion of the vertebral body demonstrable by calcification changes. Thus we have instead of decalcification as in active tuberculosis a characteristic zone of sclerosis beginning at the site of the original focus This accompanies the infiltrative process which gradually extends to involve the entire body and at times the various processes The lesions vary in size and extent Quite often they invade only an angle of the vertebral body or they may be confined to the discs but they seldom result in the narrowing of the intervertebral space by more than one half Frequently the initial lesion may be masked by concomitant periosteal reaction as evidenced by spur formation Quite frequently these appear only at the anterior margins of the bodies but in anteroposterior views these are occasionally seen to follow the contour of the discs In the more advanced or chronic stages of the disease the lesions show a reactive change increased calcification of the bodies circumscribed or diffused with proliferation of spurs across the interspace and occasionally in the more severe cases there is deformity of the body or involvement of the articular facets In many cases bony fusion takes place between adjacent bodies

Diagnosis Diagnosis can generally be made from the general symptoms of the disease plus a low white cell count and an elevated temperature with a relatively high sedimentation rate averaging 68 mm per

hour Negative Widal and tuberculosis tests are of value Various laboratory procedures also facilitate diagnosis

Treatment In such cases the disease itself must be treated first. Probably of all the various current treatments the specific vaccine offers the greatest promise of successful results When spinal complications develop, it is necessary that the patient be kept flat on a fracture mattress and quite often there is need for some means of spinal support. A spinal brace is often of advantage. In the majority of cases recovery is gained without resort to fusion

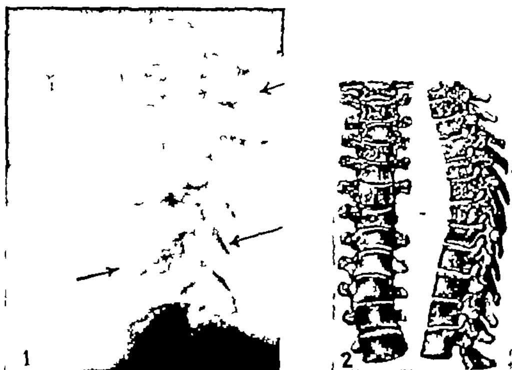


Fig. 227 1. Actinomycosis of cervical spine. (Note mottled areas in bodies and spinous processes. Death of streptococcus meningitis.) 2. Actinomycosis of the spine. (Bostrom.) *(From Diseases and Deformities of the Spine and Thorax by A. Steindler—C V Mosby Co., St Louis 1929)*

Actinomycosis of the Spine

Actinomycotic infection of the spine is not common. It occurs in only approximately two per cent of all cases of actinomycosis The involvement of the vertebrae is frequently secondary to actinomycosis of the gastrointestinal tract (Figs 1 and 2)

Clinical and Pathological Features The anterior part of the vertebrae is the region most often affected, just as in tuberculosis of the spine.

The vertebral bodies may be deeply eroded and the cord affected Destruction is more characteristic than new bone formation and is usually very extensive Large areas of soft tissues are usually involved, with the result that numerous draining sinuses are formed



Fig. 228. Blastomycosis of thoracic spine with erosion of ribs. (*From The Roentgen-Ray Diagnosis of the Diseases of the Bones and Joints by Hodges Phemister and Brunschwig Thos Nelson & Sons New York and Edinburgh 1938*)

Diagnosis Microscopic findings determine the diagnosis in every instance histologic examinations being made either of the granulation tissues or of the parts of the abscess accompanying the growth

Treatment The medical treatment of actinomycosis of the spine includes the administration of large doses of potassium iodine Surgical

treatment consists of incision and when practical, the extensive removal of the affected area, followed by immobilization in a plaster of paris jacket or spinal brace The insertion of a tibial bone graft is occasionally of value in desperate cases for added support and fusion of the spine

Blastomycosis of the Spine

Blastomycosis of the spine is a very rare condition According to Parker of the total of twenty nine cases of pyemia caused by yeast reported up to 1914 only in a very few was there spine involvement

Clinical Features and Diagnosis When the disease does attack the spine, there is a breaking down of the bodies and intervertebral discs of the involved vertebrae. Clinically the disease presents many of the symptoms of Pott s disease, from which it must be differentiated. Roentgenologically the picture is much the same as in tuberculosis, and the diag nosis most often depends entirely on the clinical and microscopic findings

Prognosis Once the condition has developed the outlook is very grave, for almost every case that has been reported has had a fatal ending

Echinococcus Disease of the Spine

Although there have been a few cases of Echinococcus cysts of the spine, the condition is quite rare. It is caused by the parasite *Taenia echinococcus* which produces multiple cysts within the bone Usually little pain is associated with the invasion by the parasite until secondary infection takes place

Treatment Treatment consists of resection and thorough curettement. This is followed by immobilization with a plaster of paris jacket or spinal brace Spinal fusion has been found necessary in the most destructive cases

Scorbutic Spondylitis of the Spine

Scorbutic spondylitis of the spine is also quite rare, and in reality is of little importance as it is merely one of the many manifestations of scurvy

Clinical Features Usually found in bottle-fed infants between the ages of six and eight months its symptoms are discomfort on spinal

movement or distress in the joints of the extremities The spine is usually very tender to palpation, although there is no evidence of redness or swelling The condition can frequently be recognized by examination of the gums after dentition and of the mucous membrane and skin following repeated small hemorrhages Occasionally an effusion of blood may occur about the joints and under the long bones as shown by x rays and epiphyseal separation is not unusual

Diagnosis This condition can usually be recognized quite readily because of the other symptoms and signs of scurvy in the child

Treatment The treatment of this condition is primarily the treatment of the disease itself In other words scurvy may be cured easily simply and solely by the addition to the diet of a sufficient amount of an antiscorbutic factor The treatment therefore is essentially dietitic and hygienic. The antiscorbutic factor is contained in such food as unpasteurized milk, raw meat fresh vegetables especially tomatoes cabbage, green peppers and potatoes Orange tomato or pineapple juice is excellent Of late years cevitamic acid has been so widely used it is almost specific for this disease It should always however be given with an adequate diet

The Rachitic Spine

Fortunately the rachitic spine is not seen nearly so often at the present time as in years past This is due first to a better understanding of the cause, prevention and treatment by the medical profession and secondly to a much broader understanding by the general public of the means of its prevention—especially in reference to ample fresh air and sunshine vegetables containing Vitamins A and D supplemented by concentrates of the same vitamins when necessary

Clinical Features The rachitic spine is always associated with manifestations of rickets elsewhere and is characterized by the absence of rigidity and the disappearance of the deformity when the child is prone with the weight borne by the chest and thighs The contour of the spine is usually a part of the general attitude in which the body is plunged forward and the spine bent in a slightly rigid posterior curve which is most marked at the junction of the dorsal and lumbar vertebrae



Fig. 229-*A*



B

Fig. 229 *A*. Rachitic spine in a child one year old. (Taylor) *B* Same child. Note disappearance of kyphos in prone posture. (Taylor) *(From Orthopaedic and Reconstruction Surgery by F H Albee W B Saunders Co)*

Diagnosis The diagnosis of rickets of the spine presents little difficulty It is associated with distortion of the lower epiphysis of the radius and ulna enlargement of the ankles and overgrowth at the junction of the ribs and costal cartilage together with delayed dentition open fontanels pigeon breast and other manifestations of the disease

Treatment With the proper care and treatment the prognosis is excellent The treatment is principally hygienic dietetic and medicinal Support of the spine is rarely necessary except in the more advanced cases where occasionally it is advisable to use a simple brace or prescribe a brief period of recumbency upon a Bradford Frame Deformity is almost always avoidable, except in those cases which are not seen until ossification of the spine in its distorted position has already taken place

Osteomalacia of the Spine

Osteomalacia of the spine is a disease of adults especially females in which case it is incident to pregnancy and prolonged lactation It is due to a deficiency of calcium and vitamin D in the diet In the past the term osteomalacia has been applied to a variety of clinical syndromes with the common characteristic of progressive softening of the skeleton due to decalcification followed by the development of the deformity However in the light of present day knowledge it is likely that many of these cases upon further study will be found to represent typical varieties of better known diseases as for instance hyperparathyroidism Yet there is a group of such cases with characteristics of such uniformity that they can be designated as a distinct clinical entity For these in more recent years the term idiopathicosteomalacia has been recommended

The exact cause of this disease is not known although a deficiency of calcium and of vitamin D in the diet is probably the primary factor in its etiology It has often been considered to be a metabolic disease of toxic origin The theory that it is an endocrine unbalance has as yet not definitely been proved or disproved

Clinical Features Although this disease is usually found among women of the Far East who subsist on a low calcium diet stay indoors most of the time and in whom pregnancy causes a marked drain on the calcium in the body occasional cases do occur among the English speaking

races During and after World War I a large number of cases of so-called hunger osteomalacia was noted in the Central European Countries This was at a time when the inhabitants of these countries subsisted on a diet low in calcium content The vast majority of cases of osteomalacia, how ever are seen in multiparas who have passed through their pregnancy under unfavorable *hygienic* and *sanitary conditions although occasional* cases do occur among children and elderly men

The condition of osteomalacia of the spine must be suspected in pa tients who complain of vague rheumatic like pains in the back and the extremities There is usually difficulty in walking, typified by a waddling gait evidence of muscular weakness accentuation of the knee jerks and presence of ankle clonus and muscular tremors The muscular weakness may become severe and progressive Due to the muscular and gravita tional stresses upon the softened spine, pelvis and long bones, deformities and pathological fractures are commonly seen The pelvis is usually the first to suffer deformity by extreme lateral flattening, producing a sharp anterior beak. The spine becomes kyphotic or scoliotic. Roentgenograms demonstrate a striking loss of calcium

The lesions are characterized by marked absorption of the lime salts *and by a congestion in the bone marrow with an increase in its lymphoid* and fatty constituents The decalcification may be so extreme that the bone is soft and flexible and may be readily cut with a knife, and a thin shell of bone which bends or breaks represents the cortex. Spontaneous fractures often marked by malunion, are common The pelvic angle at the symphysis may be markedly diminished.

Diagnosis In making the diagnosis, hyperparathyroidism, multiple myeloma, and senile osseous atrophy *and occasionally metastic carcinoma* must be considered. The x rays are most important in the differential diagnosis

Treatment The prognosis in these cases should be guarded for many of them pass through a chronic progressive course lasting many years. Some are rapidly fatal and in a few there is spontaneous cure. The treatment consists of the substitution of sanitary hygienic surroundings for insanitary ones and the giving of a diet with a *high calcium* and vitamin D content, plus an ample amount of vitamin D in the form of cod liver oil or viosterol Vitamin D concentrate may be given also

Of course, exhaustive diagnostic studies should be made in an effort to determine the causative factors and foci of infections should be treated. Fresh air and sunshine should be assured, and measures to prevent deformities, together with curative exercise and physical therapy should be instituted to counteract atrophy from disuse. In the past, double oöphorectomy in nonpregnant women has been credited with checking the disease in some instances. This, however, is of questionable value and is not recommended.

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